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A Finite Element Program for Postbuckling Calculations (PSTBKL)

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ABSTRACT

The object of the research reported herein was to develop a general mathematical model and solution methodologies for analyzing the structural response of thin, metallic shell structures under large transient, cyclic, or static thermomechanical loads. Among the system responses associated with these loads and conditions are thermal buckling, creep buckling, and ratcheting. Thus geometric and material nonlinearities (of high order) can be anticipated and must be considered in developing the mathematical model. The methodology is demonstrated through different problems of extension, shear and of planar curved beam. Moreover, importance of the inclusion of large strains is clearly demonstrated, through the chosen applications. This report describes the computer program resulting from the research.

Introduction

Program PSTBKL is developed to study the thermo-elastoviscoplastic postbuckling behavior of shell-like structures. The main features of the program include:

1. Buckling and postbuckling predictions of shell-like structures
2. Response of the structure at elevated temperatures
3. Creep buckling predictions
4. Freedom to choose different thermo-mechanical loading path
5. Bodner-Partom's constitutive equations as an elastoviscoplastic material model
6. Walker's constitutive equations as another elastoviscoplastic material model
7. Nonlinear elastic calculations
8. Crisfield's iteration schemes for limit point load problems
9. Tanaka-Miller's method used to integrate the unified constitutive equations

The program works for material B1900+Hf now. With minor change, it can work for other materials.

Input Format

File DT is the main input data file. File RD is used only when the program needs to resume a unfinished job. File RD can be copied from file WRT which is an output file in the last execution.

The format of file DT is the following:

(1). Control data (lines 1 through 8)

Line 1: I1, I2, I3, I4

I1—number of elements, I2—number of nodes, I3—number of steps planed to run, I4—maximum number of iterations allowed in each load step

Line 2: A1, A2, A3, A4, A5, A6

A1—elastic modulus of the material, A2—Poisson's ratio, A3—thickness of the structure, A4—load coefficient (take 1.0), A5—load coefficient (take 1.0), A6—initial load step (take 1.0, not use now)

Line 3: I1, I2, I3

I1—the node number of the output displacement, I2—the component of the output displacement, I3—the control variable

Line 4: I1, I2, A1, A2

I1—determine whether the execution from the beginning (choose 0) or from the last execution (choose 1), I2—number of loading steps before the program write data for further execution, A1—the displacement increment of control variable, A2—the increase rate of A1 in next step (take 1.0 generaly)

Line 5: I1, I2, I3, I4, A1, A2, A3, A4

I1—determine whether the thermal expansion is considered (take 1) or not (take 0), I2—number of steps for the change of temperature, I3—number of iterations executed before writing temporary data, I4—maximum number of iterations allowed in the equilibrium iterations, A1—thermal expansion coefficient, A2—initial temperature, A3—increment of temperature, A4—highest temperature

Line 6: I1, I2, A1, A2

I1—option whether to use unified constitutive equations (1 for yes, 0 for no), I2—option of which constitutive model to use (1 for Bodner-Partom's model and 2 for Walker's model), A1—calculation coefficient (take 1.0), A2—the increment of time in a load interval

Line 7: I1, I2

I1—option for creep calculation (1 for yes and 0 for no), I2—number of steps beyond which creep is calculated

Line 8: I1, I2

I1 and I2 are used to control the output of the calculated results. The value of I1 can be an integer from 1 to 6 which correspond to the stretch of bar, plate, cylindrical shell unter axial compression, cylindrical shell under pressure and cylindrical shell under torsion. I2 controls the way of output (see NTV in subroutine OUTPUT).

(2). Initial nodal coordinates

format: I1, A1, A2, A3

I1—node number (it does not matter whatever to write, but the real nodal number must in order of 1, 2, 3...), A1—X, A2—Y, A3—Z

(3). Constraint specification

format: I1, I2, I3, I4, I5, I6

I1—node number, I2—displacement in x direction, I3—displacement in y direction, I4—displacement in z direction, I5—rotation along local x axis, I6—rotation along local y axis (0 for free movement and 1 for constraint)

(4). Applied load

format: I1, A1, A2, A3, A4, A5

I1—node number, A1—load applied in x direction, A2—load applied in y direction, A3—load applied in z direction, A4—moment applied in local x direction, A5—moment applied in local y direction

(5). Elment and its corresponded nodes

format: I1, I2, I3, I4, I5, I6, I7, I8, I9

I1—element number, I2 through I9—the node number of the element

(6). Direction cosines of the structure

format: I1, A1, A2, A3

I1—element number, A1 through A3—the initial direction cosines of local coordinates to global coordinates at position of the node

(7). Radius and length of the shell

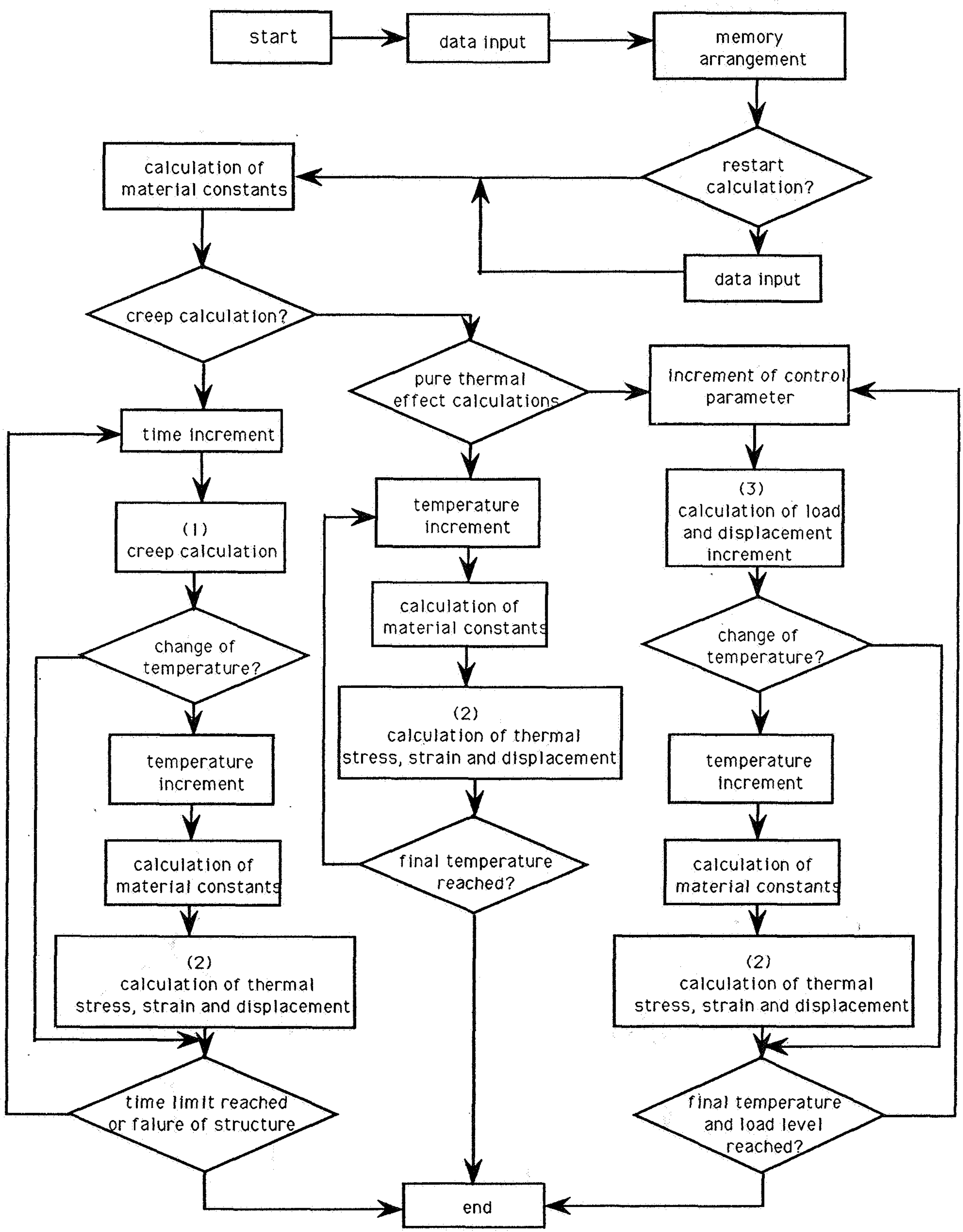
Output Files

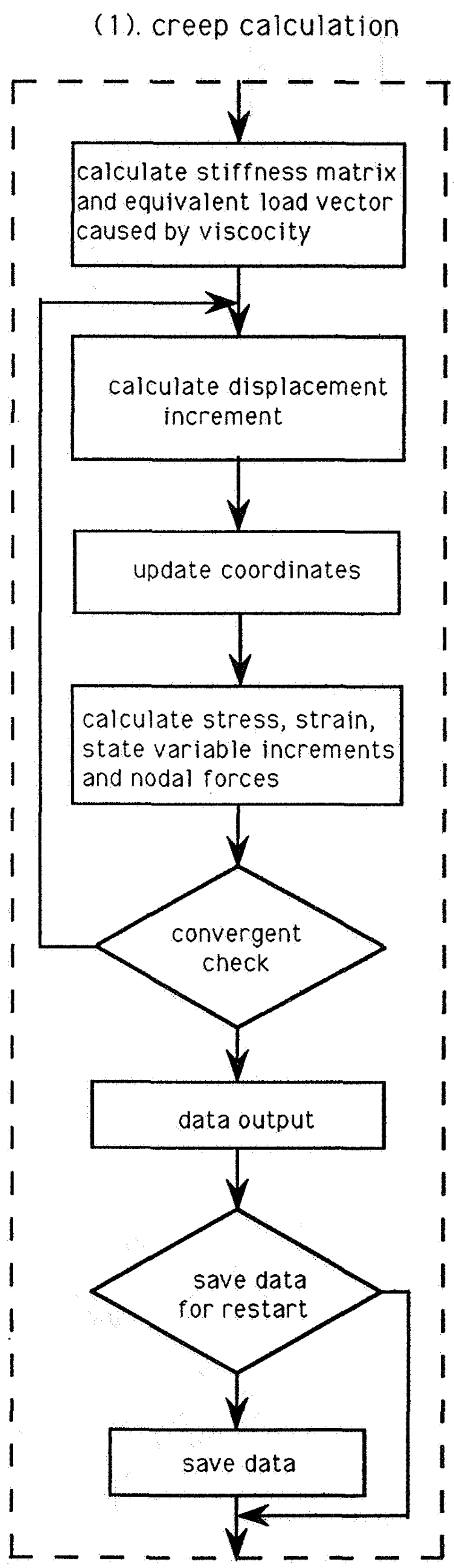
The output files are WRT, OUT, OT, OUT1, OT2 and OUT3. File WRT contains the necessary data for further execution. File OUT is the data used to locate any problem occurred during execution. Files OT, OT1, OT2 and OT3 are output files for the calculated results controlled by subroutine OUTPUT. In the subroutine, D1(I,J) is the displacement matrix where I and J are the nodal number and displacement component number, respectively. The updated coordinates of node I are XX(I), YY(I) and ZZ(I). The corresponding load can be calculated as the product of TROOT (a variable in the subroutine), load coefficient and the applied load (given in file DT). Files OT, OT1, OT2 and OT3 are associated with tape 3, 9, 11 and 12. Users can change subroutine OUTPUT to get desired output.

Subroutines from Library

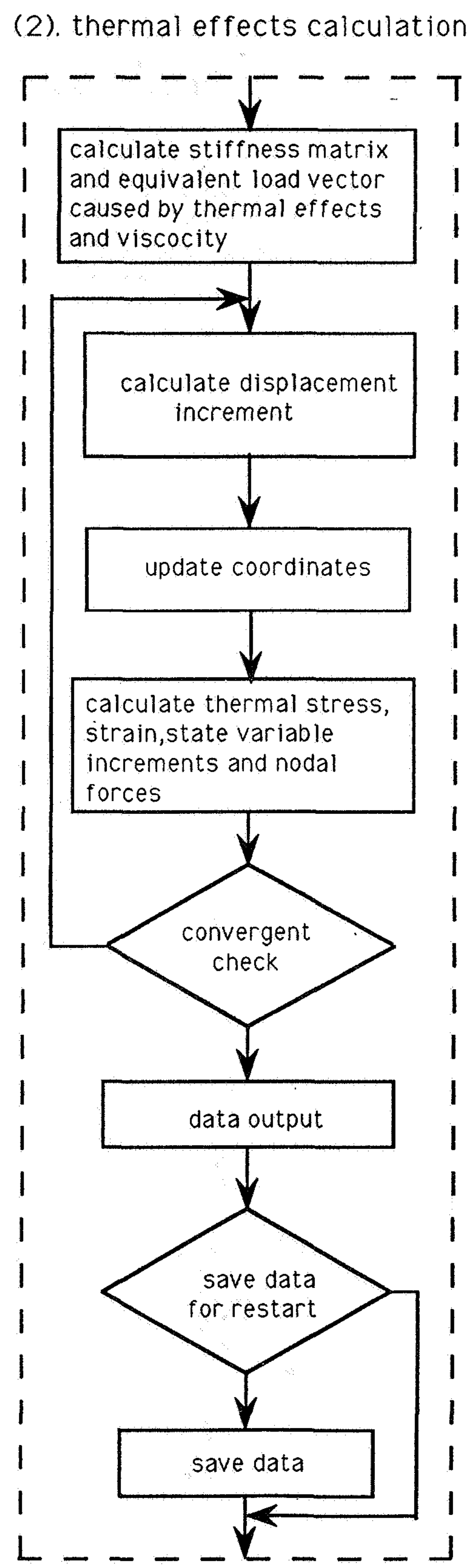
The subroutine LINRG from software IMSL is called in the program to invert the stiffness matrix. The corresponding version in Cyber is LINV3F.

Main Flowchart



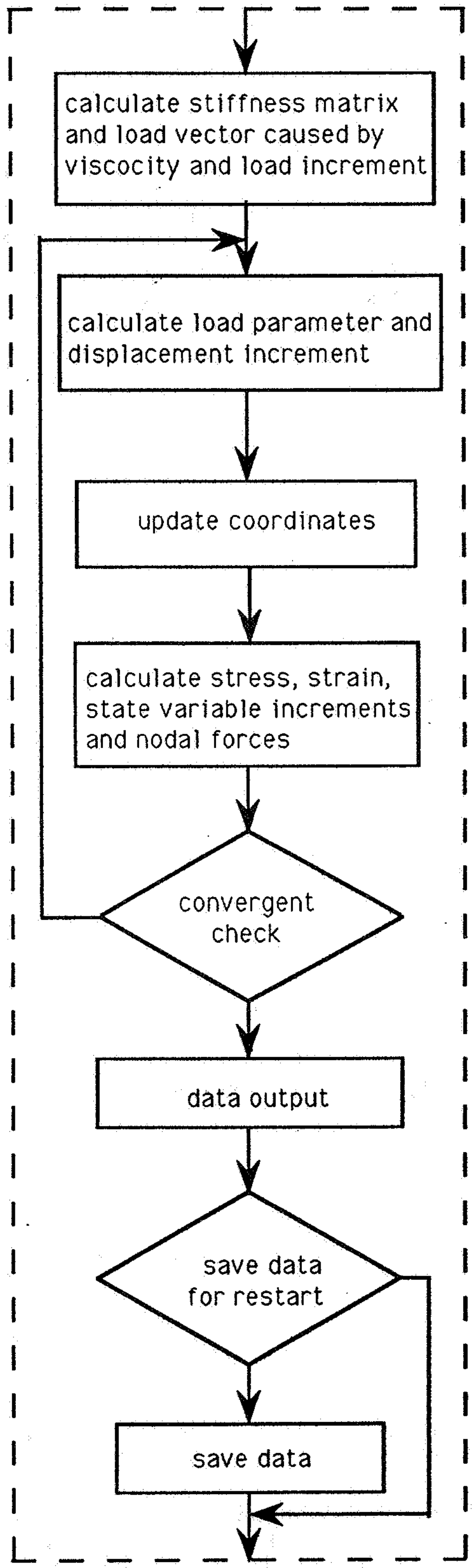


(1). creep calculation
calculate stiffness matrix and equivalent load vector caused by viscocity
calculate displacement increment
update coordinates
calculate stress, strain, state variable increments and nodal forces
convergent check
data output
save data for restart
save data



(2). thermal effects calculation
calculate stiffness matrix and equivalent load vector caused by thermal effects and viscocity
calculate displacement increment
update coordinates
calculate thermal stress, strain,state variable increments and nodal forces
convergent check
data output
save data for restart
save data

(1). calculation of load and displacement increment



```
C**********************************************************************C
C     Program pstbkl is for the postbuckling analysis with either      C
C     Bodner-Partom's or Walker's material model. The program can      C
C     deals with the following problems:                               C
C     1. Postbuckling responses of thin-walled structures under        C
C        normal loading                                                C
C     2. Creep buckling analysis                                       C
C     3. Thermal effects                                               C
C**********************************************************************C
C
      PROGRAM PSTBKL
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      PARAMETER (MAXR=150000,MAXI=5000)
      DIMENSION RWKSP(100000)
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /RLVEC/ VR(MAXR)
      COMMON /INTVEC/ IPT(MAXI)
      COMMON /WORKSP/ RWKSP
C
C     If the program is used in cyber, active 1r41=1r23 statement.
C
      OPEN(3,FILE='ot')
      OPEN(4,FILE='rd')
      OPEN(5,FILE='dt')
      OPEN(6,FILE='out')
      OPEN(7,FILE='wrt')
      OPEN(9,FILE='ot1')
      OPEN(11,FILE='ot2')
      OPEN(12,FILE='ot3')
C
      CALL CMPT1
C
C     Call cmpt1 to make initial memory arangement
C
      CALL IWKIN(100000)
C
C     IWKIN is used to set work space for subroutine LINRG wich is
C     given in IMSL library.
C
      CALL PREPC(IPT(IP1),IPT(IP2),IPT(IP3),VR(IR1),VR(IR2),
     1           VR(IR3),VR(IR4),VR(IR5),VR(IR6),VR(IR7))
C
      STOP
      END
C
C
C     Subroutine PREPC is used to read input data and make memory
C     arragement
C
      SUBROUTINE PREPC(IEL,ID,IID,XX,YY,ZZ,DD1,DD2,DLOAD,HORIZ)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION IEL(NELM,8),ID(1),IID(NNODE,5),XX(1),YY(1),ZZ(1),
     1          DD1(1),DD2(1),DLOAD(1),HORIZ(1)
C
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
```

```
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
C
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /DIRCS/ IR60,IR61,IR62,IR63,IR64,IR65
      COMMON /DISV1/ IR70,IR71,IR72,IR73,IR74,IR75
C
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
C
      CALL GETDT(IPT(IP1),IPT(IP2),IPT(IP3),IPT(IP4),IPT(IP5),
     1           IPT(IP6),IPT(IP7),IPT(IP8),VR(IR1),VR(IR2),VR(IR3),
     2           VR(IR4),VR(IR5))
C
C     Call GETDT to read data. Call CMPT2 to make memory arrangement.
C     Call RDSUP to get further data input.
C
      CALL CMPT2
      CALL RDSUP(VR(IR60),VR(IR61),VR(IR62),VR(IR63),VR(IR64),VR(IR65),
     1           VR(IR75))
C
      CALL PROCS(VR(IR6),VR(IR4),VR(IR5),VR(IR9),VR(IR27),VR(IR20),
     1           VR(IR43),VR(IR44),VR(IR45),VR(IR1),VR(IR2),VR(IR3),
     1           VR(IR47),VR(IR42),VR(IR10),VR(IR51),VR(IR58),VR(IR39))
C
      CLOSE(3)
      CLOSE(4)
      CLOSE(5)
      CLOSE(6)
      CLOSE(7)
      CLOSE(9)
      CLOSE(11)
      CLOSE(12)
      RETURN
      END
C
C     Subroutine procs is used to arrange the loading scheme, so that
C     the normal loading, creep and temperature effects can be considered
C     either simultaneously or separately.
C
      SUBROUTINE PROCS(DLOAD,DD1,DD2,PLD,ACMDIS,SIGMA,XX1,YY1,ZZ1,
     1                 XX,YY,ZZ,UPSIG,FRCINC,FRCO,BETA,UPBET,EM)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION DLOAD(1),DD1(1),DD2(1),PLD(1),ACMDIS(1),
     1          SIGMA(NELM,2,2,2,9),XX(1),YY(1),ZZ(1),XX1(1),YY1(1),
     2          ZZ1(1),UPSIG(NELM,2,2,2,9),FRCINC(1),FRCO(1),
     3          BETA(NELM,2,2,2,12),UPBET(NELM,2,2,2,12),EM(6,6)
C
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /DIRCS/ IR60,IR61,IR62,IR63,IR64,IR65
```

```
      COMMON /DISVC/ IR66,IR67,IR68,IR69
      COMMON /DISV1/ IR70,IR71,IR72,IR73,IR74,IR75
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /ITESCH/ ROOT,DTLAM,SGN,IPP,TROOT,ASO,SP
      COMMON /CNTRL/ DETMNT
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
      COMMON /ABDFST/ ISEC
      COMMON /SQ/ SQQ
      COMMON /NMBITR/ NUM
      COMMON /DISCT/ NDC,NDBC
      COMMON /CREEP/ ICRP,NBCRP,NBDN,CRPTM,IPON
      COMMON /TMPEF/ IDO,NTEM,NITR,NANM,CEXPN,TMMIN,TMINC,TMMAX,TMPP
C
      DO 10 I=1,NNODE
        XX1(I)=XX(I)
        YY1(I)=YY(I)
        ZZ1(I)=ZZ(I)
 10   CONTINUE
C
      IF (INSIDT.EQ.1) THEN
C       If the execution is based on the previous calculation, get
C       additional information
        CALL RDCDT(VR(IR27),VR(IR20),VR(IR43),VR(IR44),VR(IR45),
     1             VR(IR1),VR(IR2),VR(IR3),VR(IR47),VR(IR10),
     2             VR(IR51),VR(IR58),VR(IR60),VR(IR61),VR(IR62),
     3             VR(IR63),VR(IR64),VR(IR65),VR(IR15),VR(IR71),
     4             VR(IR75))
      END IF
C
      DO 200 J=1,NT
        DLOAD(J)=DD1(J)*COEF1
  200 CONTINUE
      ROOT=0.0
      DTLAM=FACTOR
      ROOT=ROOT+DTLAM
      SGN=1.0
      ISEC=1
C
C     Calculate material constants according to the chosen model
C
      IF(IDO.EQ.0) THEN
        TMPP=TMMIN
        IF(NCONS.EQ.0) THEN
          E=198700.0+16.78*TMPP-0.1034*TMPP*TMPP
     1       +0.00001143*TMPP*TMPP*TMPP
        ELSE
           IF(MODEL.EQ.1) CALL BDCNS(TMPP)
           IF(MODEL.EQ.2) CALL WKCNS(TMPP)
        END IF
      END IF
C
C     Calculate the elastic matrix
C
       CALL ELSMTR(EM)
C
C
      DO 220 J=1,NT
        DLOAD(J)=DD2(J)*COEF2
        PLD(J)=0.0
  220 CONTINUE
C
C     Next iteration is to calculate the thermal effect
C
      IF(IDO.EQ.1) THEN
```

```
       DO 205 I=1,NTEM
        NUM=I
        TMPP=TMINC+TMPP
        IF(NCONS.EQ.0) THEN
          E=198700.0+16.78*TMPP-0.1034*TMPP*TMPP
     1      +0.00001143*TMPP*TMPP*TMPP
        ELSE
           IF(MODEL.EQ.1) CALL BDCNS(TMPP)
           IF(MODEL.EQ.2) CALL WKCNS(TMPP)
        END IF
C
        IF(TMPP.GT.TMMAX) THEN
          WRITE(6,*) 'THE MAXIMAM LIMIT OF TEMPERATURE IS REACHED, STOP'
          STOP
        END IF
C
        CALL THRML(I,IPT(IP1),IPT(IP2),IPT(IP3),IPT(IP4),IPT(IP5),
     1        IPT(IP9),VR(IR1),VR(IR2),VR(IR3),VR(IR6),VR(IR8),
     2        VR(IR9),VR(IR10),VR(IR11),VR(IR12),VR(IR13),VR(IR14),
     3        VR(IR15),VR(IR16),VR(IR17),VR(IR21),VR(IR22),VR(IR23),
     4        VR(IR24),VR(IR18),VR(IR26),VR(IR27),VR(IR42),VR(IR43),
     5        VR(IR44),VR(IR45),VR(IR46),VR(IR47),VR(IR20),VR(IR48),
     6        VR(IR49),VR(IR19),VR(IR50),VR(IR51),VR(IR58),VR(IR59),
     7        VR(IR60),VR(IR61),VR(IR62),VR(IR63),VR(IR64),VR(IR65),
     8        VR(IR4))
  205  CONTINUE
      END IF
C
C     Next iteration is to calculate creep responses (with or without
C     thermal effects) or the normal loading responses (with or withour
C     thermal effects)
C
      DO 900 I=1,NSTEP
       ROOT=0.0
       NUM=I
       IF(NBDN.GT.NBCRP.AND.ICRP.EQ.1) THEN
        CALL NTCRP(I,IPT(IP1),IPT(IP2),IPT(IP3),IPT(IP4),IPT(IP5),
     1        IPT(IP9),VR(IR1),VR(IR2),VR(IR3),VR(IR6),VR(IR8),
     2        VR(IR9),VR(IR10),VR(IR11),VR(IR12),VR(IR13),VR(IR14),
     3        VR(IR15),VR(IR16),VR(IR17),VR(IR21),VR(IR22),VR(IR23),
     4        VR(IR24),VR(IR18),VR(IR26),VR(IR27),VR(IR42),VR(IR43),
     5        VR(IR44),VR(IR45),VR(IR46),VR(IR47),VR(IR20),VR(IR48),
     6        VR(IR49),VR(IR19),VR(IR50),VR(IR51),VR(IR58),VR(IR59),
     7        VR(IR60),VR(IR61),VR(IR62),VR(IR63),VR(IR64),VR(IR65),
     8        VR(IR66),VR(IR67),VR(IR68),VR(IR69),VR(IR71),VR(IR72),
     9        VR(IR73),VR(IR75),VR(IR74))
       ELSE
        CALL ARCLS(I,IPT(IP1),IPT(IP2),IPT(IP3),IPT(IP4),IPT(IP5),
     1        IPT(IP9),VR(IR1),VR(IR2),VR(IR3),VR(IR6),VR(IR8),
     2        VR(IR9),VR(IR10),VR(IR11),VR(IR12),VR(IR13),VR(IR14),
     3        VR(IR15),VR(IR16),VR(IR17),VR(IR21),VR(IR22),VR(IR23),
     4        VR(IR24),VR(IR18),VR(IR26),VR(IR27),VR(IR42),VR(IR43),
     5        VR(IR44),VR(IR45),VR(IR46),VR(IR47),VR(IR20),VR(IR48),
     6        VR(IR49),VR(IR19),VR(IR50),VR(IR51),VR(IR58),VR(IR59),
     7        VR(IR60),VR(IR61),VR(IR62),VR(IR63),VR(IR64),VR(IR65),
     8        VR(IR66),VR(IR67),VR(IR68),VR(IR69),VR(IR71),VR(IR72),
     9        VR(IR73),VR(IR75),VR(IR74))
C
       END IF
       IF(IDO.EQ.2) THEN
        TMPP=TMINC+TMPP
         IF(NCONS.EQ.0) THEN
           E=198700.0+16.78*TMPP-0.1034*TMPP*TMPP
     1       +0.00001143*TMPP*TMPP*TMPP
         ELSE
            IF(MODEL.EQ.1) CALL BDCNS(TMPP)
```

```
         IF(MODEL.EQ.2) CALL WKCNS(TMPP)
      END IF
      CALL THRML(I,IPT(IP1),IPT(IP2),IPT(IP3),IPT(IP4),IPT(IP5),
     1           IPT(IP9),VR(IR1),VR(IR2),VR(IR3),VR(IR6),VR(IR8),
     2           VR(IR9),VR(IR10),VR(IR11),VR(IR12),VR(IR13),VR(IR14),
     3           VR(IR15),VR(IR16),VR(IR17),VR(IR21),VR(IR22),VR(IR23),
     4           VR(IR24),VR(IR18),VR(IR26),VR(IR27),VR(IR42),VR(IR43),
     5           VR(IR44),VR(IR45),VR(IR46),VR(IR47),VR(IR20),VR(IR48),
     6           VR(IR49),VR(IR19),VR(IR50),VR(IR51),VR(IR58),VR(IR59),
     7           VR(IR60),VR(IR61),VR(IR62),VR(IR63),VR(IR64),VR(IR65),
     9           VR(IR4))
C
        DO 221 J=1,NT
          DLOAD(J)=DD2(J)*COEF2
          PLD(J)=0.0
  221   CONTINUE
       END IF
  900 CONTINUE
C
      RETURN
      END
C
C
C     Subroutine ARCLS is used for normal loading calculation.
C     Arc-length method is used in the iteration scheme.
C
      SUBROUTINE ARCLS(INUM,IEL,ID,IID,L,MAXA,LD,XX,YY,ZZ,DLOADT,D,
     1                 PLD,FRCO,DD,DLDINC,VTEMP,VF,D1,VFE,DDD,AM,PD,
     2                 P,A,TDLD,HISINC,ACMDIS,FRCINC,XX1,YY1,ZZ1,DELTA,
     3                 UPSIG,SIGMA,DLTINC,DLTTMP,STIFFN,EXLVC,BETA,UPBET,
     4                 ACTFRC,GCL1,GCL2,GCL3,UCL1,UCL2,UCL3,ADC,ADD,AD,
     5                 ADVC,TLTY,TY1,TY2,ANGL,DBVC)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
C
      DIMENSION IEL(NELM,8),ID(1),IID(NNODE,5),L(1),MAXA(1),LD(1)
      DIMENSION XX(1),YY(1),ZZ(1),DD(NNODE,5),D(1),PLD(1),
     1          DLOADT(1),DLDINC(1),VTEMP(1),VF(NNODE,5),
     2          D1(NNODE,5),VFE(NT,1),DDD(1),VRT(4),
     3          A(NEQT,NEQT),AM(40,40),PD(1),TDLD(1),
     4          HISINC(1),ACMDIS(1),FRCINC(1),XX1(1),YY1(1),ZZ1(1),
     5          DELTA(1),FRCO(1),UPSIG(NELM,2,2,2,9),ACTFRC(1),
     6          SIGMA(NELM,2,2,2,9),DLTINC(1),DLTTMP(1),COEEQ(5),
     7          DEFVRT(4),STIFFN(NT,NT),ETT(4),EXLVC(1),
     8          BETA(NELM,2,2,2,12),UPBET(NELM,2,2,2,12),GCL1(NNODE,3),
     9          GCL2(NNODE,3),GCL3(NNODE,3),UCL1(NNODE,3),
     1          UCL2(NNODE,3),UCL3(NNODE,3),ADC(NDBC,NDBC),
     2          ADD(NDBC,NEQT),AD(NEQT,NDBC),ADVC(1),TLTY(1),TY1(1),
     3          TY2(1),ANGL(1),DBVC(1)
C
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /DIRCS/ IR60,IR61,IR62,IR63,IR64,IR65
      COMMON /DISCT/ NDC,NDBC
      COMMON /DISVC/ IR66,IR67,IR68,IR69
      COMMON /DISV1/ IR70,IR71,IR72,IR73,IR74,IR75
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
```

```
C     Begin iteration
C
      III=1
C
      CALL MNU(NNODE,5,VF)
      DO 200 I=1,NT
         DLDINC(I)=DLOADT(I)
  200 CONTINUE
C
      DO 195 I=1,ND
         TDLD(I)=0.0
         HISINC(I)=0.0
  195 CONTINUE
  210 FORMAT('I,LDINC,LOADT,PLD IS',I13,3F8.3)
  579 CONTINUE
C
C     Call ASSMBL is to form the stiffeness matrix
C
         CALL ASSMBL(III,IPT(IP1),IPT(IP2),IPT(IP3),IPT(IP4),IPT(IP5),
     1         IPT(IP9),VR(IR1),VR(IR2),VR(IR3),VR(IR6),VR(IR8),
     2         VR(IR12),VR(IR14),VR(IR15),VR(IR16),VR(IR19),VR(IR21),
     3         VR(IR23),VR(IR24),VR(IR19),VR(IR41),VR(IR50),VR(IR52),
     4         VR(IR66),VR(IR67),VR(IR68),VR(IR74))
C
C
      ICDD=1
      IF(III.GT.2) GOTO 577
      IF(NDC.EQ.1) THEN
C       For displacement boundary value problem, calculate ADVC
        CALL DISBN(VR(IR69),VR(IR75))
        DO 570 I=1,ND
          DDD(I)=0.0
          DO 570 J=1,NDBC
            DDD(I)=DDD(I)+AD(I,J)*ADVC(J)
  570   CONTINUE
  533   FORMAT(I13,6F9.3)
        DO 572 I=1,ND
          DDD(I)=D(I)-DDD(I)
  572   CONTINUE
      END IF
      IF(NDC.EQ.0) THEN
        DO 573 I=1,ND
          DDD(I)=D(I)
  573   CONTINUE
      END IF
   16 FORMAT('D(I) AND DDD(I): ',I13,2F14.5)
C
  577 CONTINUE
       WRITE(6,36) III
   36 FORMAT('THIS IS THE ITERATION ',I13)
      IF(III.EQ.ITRLM) THEN
        WRITE(6,*) 'ITERATION LIMIT REACHED. STOP.'
        STOP
      END IF
C
      IF(III.EQ.1) THEN
        DO 444 I=1,ND
          DO 444 J=1,ND
            TDLD(I)=TDLD(I)+A(I,J)*DDD(J)
  444   CONTINUE
C
        DO 755 I=1,ND
          VTEMP(I)=0.0
          DO 755 J=1,ND
            VTEMP(I)=VTEMP(I)+STIFFN(I,J)*TDLD(J)
  755   CONTINUE
```

```
      ASL=0.0
      DO 857 I=1,ND
        ASL=ASL+VTEMP(I)*TDLD(I)
857   CONTINUE
       WRITE(6,*) 'ASL    ',ASL

      ETA=1.0
C
C     Next statement is important. It determines the controvariable.
C
        FAC=DTLM1/ABS(TDLD(NSHOW3))
        FAC=DTLM1/ABS(TDLD(ND-NSHOW3))
        WRITE(6,*) 'TDELT=',TDELT
      IF(ASL.LT.0.0) THEN
        FAC=-FAC
        WRITE(6,*) 'CHANGED SIGN OF FAC'
      END IF
      IF(DETMNT.LT.0.0) WRITE(6,*) 'NEG. DET. STOP'
      IF(DETMNT.GT.0.0) FAC=ABS(FAC)
      DO 550 I=1,ND
        DLTTMP(I)=0.0
        DELTA(I)=0.0
        VTEMP(I)=0.0
        FRCINC(I)=0.0
550   CONTINUE
     END IF
C
C    Finish iii=1 calculation.
C    Next to calculate the start point displasment HISINC(I)
C
C
C    ACCELERATION COMPUTATION
C
     IF((III.EQ.1).OR.(III.EQ.2)) GOTO 624
     D55=D5
     D66=D6
     D77=D7
     E11=E1
     E22=E2
C
C    Prepare the coefficients of the equation which determines the
C    load parameter.
C
     CALL CALCDT(ND,DTL,ROOT,FAC,C1,C2,D11,D2,D3,D4,D5,D6,D7,A4,
    1      VR(IR18),VR(IR17),VR(IR26),VR(IR46),VR(IR42))
C
     ETAO=ETA
     ROOTO=ROOT
     KK=0
C
     RTL=ROOT
     WRITE(6,*) 'RTL=',RTL
C    Calculate the root of the equation
     CALL CLCRT(ETAO,ETA,ATERM,C1,D11,D2,D3,D4,A4,DTL,ROOT)
     ETA=1.0
624  CONTINUE
C
C    No acceleration iteration
C
     IF((III.EQ.1).OR.(III.EQ.2)) THEN
C
C    For first and second iterations, there is no acceleration calculation
C
      ETA=1.0
      CALL CALCDT(ND,DTL,ROOT,FAC,C1,C2,D11,D2,D3,D4,D5,D6,D7,A4,
```

```
     1       VR(IR18),VR(IR17),VR(IR26),VR(IR46),VR(IR42))
C
       IF(III.EQ.1) GOTO 625
         CALL CLCRT(ETAO,ETA,ATERM,C1,D11,D2,D3,D4,A4,DTL,ROOT)
       END IF
       WRITE(6,*) 'III=',III
C
  625 CONTINUE
C
C     Calculate the displacement increment
C
      DO 635 I=1,ND
        DLTINC(I)=0.0
        IF(III.EQ.1) THEN
          IF(NCONS.EQ.1) THEN
            DO 634 J=1,ND
              DLTINC(I)=DLTINC(I)+A(I,J)*EXLVC(J)
  634       CONTINUE
            DLTINC(I)=FAC*TDLD(I)+DLTINC(I)
          ELSE
            DLTINC(I)=FAC*TDLD(I)
          END IF
          ROOT=FAC
        ELSE
          DLTINC(I)=ETA*(HISINC(I)+ROOT*TDLD(I))
        END IF
        DELTA(I)=DLTTMP(I)+DLTINC(I)
  635 CONTINUE
      IF  (III.EQ.1) THEN
        WRITE(6,*) 'FIRST ITERATION OF STEP ',NUM
      END IF
      I=NEQT
C       WRITE(6,*) 'CURRENT ROOT ',ROOT
C       WRITE(6,*) 'TDLD(25)  ',TDLD(I)
C       WRITE(6,*) I,' ROOT*TDLD ',ROOT*TDLD(I)
C       WRITE(6,*) I,' FRCINC     ',FRCINC(I)
C       WRITE(6,*) I,' HISINC ',HISINC(I)
C       WRITE(6,*) I,' DLTINC ',DLTINC(I)
C       WRITE(6,*) I,' DELTA ',DELTA(I)
C
C
      K=1
      KK=1
      DO 580 I=1,NNODE
       DO 580 J=1,5
         IF(IID(I,J).EQ.0) THEN
           VF(I,J)=DLTINC(K)
           DD(I,J)=DLTINC(K)
           K=K+1
         END IF
         IF(IID(I,J).EQ.2) THEN
           VF(I,J)=(ROOT-RTL)*ADVC(KK)
           DD(I,J)=VF(I,J)
           KK=KK+1
         END IF
  580  CONTINUE
  586  FORMAT(I13,5F12.8)
C
C
      DO 901 I=1,NNODE
        DO 901 J=1,5
          VFE(I*5-5+J,1)=VF(I,J)
  901 CONTINUE
  302 FORMAT('I,VFE(I) IS: ',2I2,1F12.6)
C
C     Estimation of the new coordinates
```

```
C
      TINC=1.0
C
C     Update the coordinates
C
      DO 900 I=1,NNODE
        XX(I)=XX(I)+TINC*DD(I,1)
        YY(I)=YY(I)+TINC*DD(I,2)
        ZZ(I)=ZZ(I)+TINC*DD(I,3)
        TMP=0.0
        DO 903 J=1,3
        GCL3(I,J)=GCL3(I,J)+TINC*(-GCL2(I,J)*DD(I,4)+GCL1(I,J)*DD(I,5))
        TMP=TMP+GCL3(I,J)*GCL3(I,J)
  903   CONTINUE
        TMP=TMP**0.5
        DO 902 J=1,3
          GCL3(I,J)=GCL3(I,J)/TMP
  902   CONTINUE
C       WRITE(6,267) I,XX(I),YY(I),ZZ(I)
  900 CONTINUE
C
C     Update the directional cosines
C
      CALL CNND(VR(IR60),VR(IR61),VR(IR62))
C
C     Calculate internal forces
C
      CALL INTFRC(III,IPT(IP1),VR(IR1),VR(IR2),VR(IR3),
     1            VR(IR14),VR(IR22),VR(IR28),VR(IR9))
C
C     SHRINK THE INTERNAL FORCE VECTOR
C
      DO 500 I=1,NT
      DO 500 M=1,ND
        IF(I.EQ.L(M)) THEN
           FRCINC(M)=(PLD(I)-FRCO(M))
           ACTFRC(M)=PLD(I)
        END IF
  500 CONTINUE
C
C
        DO 447 I=1,ND
          HISINC(I)=0.0
  447   CONTINUE
        DO 448 I=1,ND
          DO 449 J=1,ND
            HISINC(I)=HISINC(I)-A(I,J)*FRCINC(J)
  449     CONTINUE
C           WRITE(6,*) I,'  HISINC=',HISINC(I)
  448   CONTINUE
C
        DO 549 I=1,ND
          EXLVC(I)=0.0
          TDLD(I)=0.0
          DO 446 J=1,ND
            TDLD(I)=TDLD(I)+A(I,J)*DDD(J)
  446     CONTINUE
  549   CONTINUE
C
C     Check whether to step out of the iterations
C
      ISWTCH=0
      ISEC=ISEC+1
      IF(ISEC.GT.10) ISEC=10
C     WRITE(6,*) 'I, DDD(I), ROOT*DDD(I),FRCINC(I), EXLVC(I)'
C
```

```
      DO 665 I=1,ND
        DLTTMP(I)=DELTA(I)
        ACMDIS(I)=ACMDIS(I)+DLTINC(I)
C     WRITE(6,*) I,' ACMDIS ',ACMDIS(I)
  665 CONTINUE
C
      K=1
      DO 585 I=1,NNODE
       DO 585 J=1,5
         IF(IID(I,J).EQ.0) THEN
           D1(I,J)=ACMDIS(K)
           K=K+1
         END IF
  585  CONTINUE
C
      CALL CRITR1(III,ND,VR(IR8),VR(IR42),VR(IR59),VR(IR17),
     1            VLINIT,ICNC1,VALS)
      WRITE(6,*) 'VLINIT=',VLINIT
C     IF(ICNC1.EQ.0) THEN
C       IF(III.EQ.1) VLS1=VALS
C       IF(III.EQ.2) VLS2=VALS
C       IF(III.GT.2) THEN
C         IF(VALS.GT.VLS1.AND.VALS.GT.VLS2) THEN
C          WRITE(6,*) 'BREAK=',LIM
C          DTLM1=DTLM1/2.0
C           LIM=LIM+1
C           IF(LIM.EQ.20) THEN
C             WRITE(6,*) 'Break limit reached, stop'
C             STOP
C           END IF
C           GOTO 1000
C          ELSE
C           VLS1=VLS2
C           VLS2=VALS
C           LIM=0
C         END IF
C       END IF
C     END IF
C
      IF((ICONCL.EQ.1).OR.(ICNC1.EQ.1)) THEN
C       IF(III.LT.3.AND.NUM.LT.24) DTLM1=DTLM1*SQQ
        DTLM1=DTLM1*SQQ
C       IF(III.LE.4) DTLM1=DTLM1*1.1
        IF(III.GE.8.AND.III.LT.10) DTLM1=DTLM1/1.1
        IF(III.GE.10.AND.III.LT.15) DTLM1=DTLM1/1.2
        IF(III.GE.15) DTLM1=DTLM1/1.0
        WRITE(6,*) 'FIN VAL OF III=',III,' NDTLM1=',DTLM1
        TROOT=TROOT+ROOT
C
C     For displacement boundary problem:
C
        IF(NDC.EQ.1) THEN
        KK=1
        DO 590 I=1,NNODE
          DO 590 J=1,5
            IF(IID(I,J).EQ.2) THEN
              D1(I,J)=D1(I,J)+ROOT*ADVC(KK)
              KK=KK+1
            END IF
  590     CONTINUE
      DO 599 I=1,20
        WRITE(6,*) I,' D1=',(D1(I,J),J=1,5)
  599 CONTINUE
C     CALCULATE BOUNDARY TRACTION
          TTLD=0.0
          DO 636 I=1,NDBC
```

```
          TY1(I)=0.0
          TY2(I)=0.0
          DO 637 J=1,ND
            TY1(I)=TY1(I)+ADD(I,J)*DELTA(J)
 637      CONTINUE
          DO 638 J=1,NDBC
            TY2(I)=TY2(I)+ADC(I,J)*ADVC(J)*ROOT
 638      CONTINUE
          TLTY(I)=TLTY(I)+TY1(I)+TY2(I)-DBVC(I)
C         WRITE(6,*) I,' TLTY=',TLTY(I)
          TTLD=TTLD+TLTY(I)
        WRITE(6,*) I,' TY1=',TY1(I),'  TY2=',TY2(I),' TLTY=',TLTY(I)
 636    CONTINUE
        WRITE(6,*) 'TTLD=',TTLD
      END IF
C
      CRPTM=CRPTM+TDELT
C
C     For a sucsessful iteration, write the output data.
C
      CALL OUTPUT(TTLD,VR(IR15),VR(IR75),VR(IR71),VR(IR1),VR(IR2),
     1            VR(IR3))
C
      ITYPE=1
C
C     For successful iteration, update some variables.
C
      CALL UPDT(ITYPE,IPT(IP3),VR(IR1),VR(IR2),VR(IR3),VR(IR12),
     1      VR(IR15),VR(IR27),VR(IR43),VR(IR44),VR(IR45),
     2      VR(IR46),VR(IR47),VR(IR20),VR(IR48),VR(IR49),
     3      VR(IR51),VR(IR58),VR(IR60),VR(IR61),VR(IR62),
     4      VR(IR63),VR(IR64),VR(IR65),VR(IR75))
C
     ELSE
C
C     If the iteration requiment is not satisfied, calculate the
C     following coefficients and go back to the iterations again.
C
      III=III+1
      E1=0.0
      E2=0.0
      DO 510 I=1,ND
        E1=E1+HISINC(I)*FRCINC(I)
        E2=E2+TDLD(I)*FRCINC(I)
 510  CONTINUE
      ICDD=ICDD+1
C     IF(ICDD.GT.4) THEN
C       GOTO 579
C     ELSE
        GOTO  577
C     END IF
     END IF
 670 CONTINUE
C
      DO 555 I=1,ND
        DO 555 J=1,ND
          VTEMP(I)=VTEMP(I)+STIFFN(I,J)*DELTA(J)
C         IF(I.EQ.J) THEN
C           WRITE(6,*) 'STIFFN2 ',STIFFN(I,J)
C         END IF
 555  CONTINUE
C
      ASLOP=0.0
      DO 557 I=1,ND
        ASLOP=ASLOP+VTEMP(I)*DELTA(I)
 557  CONTINUE
```

```
          ASLOP=ASLOP/ABS(ASLOP)
          IF(NUM.EQ.1)   ASO=ASLOP/ROOT/ROOT
          ASI=ASLOP/ROOT/ROOT
           WRITE(6,*)  'NUM ',NUM
C          WRITE(6,*)  'ASO, ASI ',ASO,ASI
          SP=ASO/ASI
C          WRITE(6,*)  'SP '.SP
C
        DO 730 I=1,ND
          FRCO(I)=FRCO(I)+FRCINC(I)
  730   CONTINUE
          IF  (KPDT.EQ.NUM)  THEN
C
C          If the required number of iterations has reached, save the
C          nessisary data in harddisk. It can be used for further calculation.
C
           CALL WTCDT(VR(IR27),VR(IR20),VR(IR43),VR(IR44),
     1                 VR(IR45),VR(IR1),VR(IR2),VR(IR3),
     1                 VR(IR47),VR(IR10),VR(IR51),VR(IR58),VR(IR60),
     3                 VR(IR61),VR(IR62),VR(IR15),VR(IR71),VR(IR75))
          END IF
 1000   CONTINUE
        RETURN
        END
C       END ARCLS
C
C       Subroutine CALCDT is used to calculate the coefficients of
C       the equation which determines the load parameter
C
        SUBROUTINE CALCDT(ND,DTL,ROOT,FAC,C1,C2,D11,D2,D3,D4,D5,D6,D7,
     1                 A4,TDLD,D,HISINC,DELTA,FRCINC)
        IMPLICIT REAL*8(A-H,O-Z)
        IMPLICIT INTEGER*8(I-N)
        DIMENSION TDLD(1),D(1),HISINC(1),DELTA(1),FRCINC(1)
        COMMON /SCHALR1/ NELM,NNODE,NT
        COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                   NSHOW3,HRZ,ITRLM,FACTOR
        COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
        COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                  IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                  IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                  IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                  IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                  IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
        COMMON /RLVEC/ VR(1)
        COMMON /INTVEC/ IPT(1)
C
C
        C1=0.0
        C2=0.0
        D11=0.0
        D2=0.0
        D3=0.0
        D4=0.0
        D5=0.0
        D6=0.0
        D7=0.0
        A4=0.0
C
        DO 652 I=1,ND
C          WRITE(6,*)  'TDLD ',TDLD(I),'HISINC ',HISINC(I),'DELTA ',DELTA(I)
C          WRITE(6,*)  'I= ',I,'D(I)  ',D(I),'FRCINC ',FRCINC(I)
          C1=C1+TDLD(I)*TDLD(I)
          C2=C2-TDLD(I)*D(I)
          D11=D11+TDLD(I)*DELTA(I)
          D2=D2+TDLD(I)*HISINC(I)
```

```
         D3=D3+HISINC(I)*HISINC(I)
         D4=D4+HISINC(I)*DELTA(I)
         D5=D5-HISINC(I)*D(I)
         D6=D6+HISINC(I)*FRCINC(I)
         D7=D7+TDLD(I)*FRCINC(I)
  652 CONTINUE
C     WRITE(6,*) 'C1=',C1,'  D1=',D11,'  D2=',D2
C     WRITE(6,*) 'D3=',D3,'  D4=',D4
C
      DTL=FAC*FAC*C1
      DO 660 I=1,ND
        A4=A4+DELTA(I)*DELTA(I)
  660 CONTINUE
C      WRITE(6,*) 'A4, DTL ',A4,DTL
C
      A4=A4-DTL
C      WRITE(6,*) 'A4 FIN. ',A4
C
      RETURN
      END
C
C     Nextsubroutine culculates the roots of eqs. for lamda(i+1)
C
      SUBROUTINE CLCRT(ETAO,ETA,ATERM,C1,D1,D2,D3,D4,A4,DTL,ROOT)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
C
      K=0
   20 CONTINUE
      K=K+1
      IF(K.EQ.10) THEN
        WRITE(6,*) 'NEGATIVE VALUE FOR SQRT OPER. APPROXM. GIVEN'
        WRITE(6,*) 'THE SQUARE VALUE ',UDRT
        ROOT=-A2/2.0/A1
        GOTO 200
      END IF
      A1=ETA*C1+ATERM
      A2=2.0*D1+2.0*ETA*D2
      A3=ETA*D3+2.0*D4
       WRITE(6,*) 'A1,A2,A3 ',A1,'  ',A2,'   ',A3
      IF  (ABS(A3).LT.0.00000000001) THEN
        ROOT=-A2/A1
        WRITE(6,*) 'ATTENTION: A3=0'
        RETURN
      END IF
C
C
C     SOLVE THE EQUATION FOR LAMDA(I+1)
C
      UDRT=A2*A2-4.0*A1*A3
      IF(UDRT.LT.0.0) THEN
        WRITE(6,*) 'NEGATIVE VALUE FOR THE ROOT, STOP.'
        STOP
        ETA=(ETA+ETAO)/2.0
        GOTO 20
      END IF
        ROOT1=(-A2+SQRT(UDRT))/2.0/A1
        ROOT2=(-A2-SQRT(UDRT))/2.0/A1
        CS1=1.0+ETA*(D4+ROOT1*D1)/DTL
        CS2=1.0+ETA*(D4+ROOT2*D1)/DTL
C        WRITE(6,*) 'ROOT1,ROOT2 ',ROOT1,ROOT2
C        WRITE(6,*) 'CS1,CS2 ',CS1,CS2
        IF((CS1.LT.0.0).AND.(CS2.GT.0.0)) THEN
          ROOT=ROOT2
        ELSE
          IF((CS2.LT.0.0).AND.(CS1.GT.0.0)) THEN
```

```
            ROOT=ROOT1
          ELSE
            IF (ABS (ROOT1+A3/A2) .LT.ABS (ROOT2+A3/A2)) THEN
            IF (ABS (ROOT1-1.0) .LT.ABS (ROOT2-1.0)) THEN
               ROOT=ROOT1
            ELSE
               ROOT=ROOT2
            END IF
          END IF
        END IF
C
  200 CONTINUE
      RETURN
      END
C
C     Subroutine ASSMBL install the stiffness matrix and the load vector
C
      SUBROUTINE ASSMBL(III,IEL,ID,IID,L,MAXA,LD,XX,YY,ZZ,DD,D,
     1                  DLDINC,VF,D1,VFE,TS,AM,P,A,STIFFN,AINV,EXLVC,
     2                  TXVC,ADC,ADD,AD,DBVC)
      IMPLICIT REAL*8 (A-H,O-Z)
      IMPLICIT INTEGER*8 (I-N)
      DIMENSION IEL(NELM,8),ID(1),IID(NNODE,5),L(1),MAXA(1),LD(1)
      DIMENSION XX(1),YY(1),ZZ(1),DD(1),D(1),EXLVC(1),
     1          DLDINC(1),VF(NNODE,5),TXVC(1),
     2          D1(NNODE,5),VFE(NT,1),TS(NT,NT),P(1),EXLD(40),
     3          A(NEQT,NEQT),AM(40,40),AINV(1),STIFFN(NT,NT),
     4          ADC(NDBC,NDBC),ADD(NDBC,NEQT),AD(NEQT,NDBC),DBVC(1)
C
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /DIRCS/ IR60,IR61,IR62,IR63,IR64,IR65
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /CNTRL/ DETMNT
      COMMON /DISCT/ NDC,NDBC
      COMMON /DISVC/ IR66,IR67,IR68,IR69
      COMMON /TIDF/ IDF
C
C
      CALL MNU(NT,NT,TS)
      DO 20 I=1,NT
        EXLVC(I)=0.0
        TXVC(I)=0.0
   20 CONTINUE
C
C     Calculation in defferent element
C
      DO 140 I=1,NELM
      I1=IEL(I,1)
      I2=IEL(I,2)
      I3=IEL(I,3)
      I4=IEL(I,4)
      I5=IEL(I,5)
      I6=IEL(I,6)
      I7=IEL(I,7)
```

```
      I8=IEL(I,8)

      Calculate the element stiffness.

      CALL CESM(III,I,I1,I2,I3,I4,I5,I6,I7,I8,VR(IR21),VR(IR1),
     1          VR(IR2),VR(IR3),VR(IR14),VR(IR25),EXLD,VR(IR60),
     2          VR(IR61),VR(IR62))
C
C     Build the globle stiffness matrix
C
      DO 140 J=1,8
        DO 140 K=1,5
          JJ=IEL(I,J)*5-5+K
          J1=J*5-5+K
          IF(NCONS.EQ.1) THEN
             TXVC(JJ)=TXVC(JJ)+EXLD(J1)
          END IF
          DO 140 M=1,8
            DO 140 N=1,5
              MM=IEL(I,M)*5-5+N
              M1=M*5-5+N
C              IF(MM.LE.JJ) THEN
               TS(JJ,MM)=TS(JJ,MM)+AM(J1,M1)
C              WRITE(6,143) IEL(I,J),JJ,MM,J1,M1,TS(JJ,MM)
C              END IF
C
  140 CONTINUE
  143 FORMAT('ST IS',5I4,1F15.3)
 1200 CONTINUE
C
      J=1
      JD=1
      DO 150 I=1,NT
        IF(ID(I).EQ.0) THEN
          L(J)=I
          J=J+1
        END IF
        IF(ID(I).EQ.2) THEN
          LD(JD)=I
          JD=JD+1
        END IF
  150 CONTINUE
C
      IDF=J-1
      JJD=JD-1
      WRITE(6,*) 'JJD=',JJD,' IDF=',IDF
C
C     idf is the number of unknown disp.
C     jjd is the number of given disp.
C
  200 CONTINUE
C
  210 FORMAT('I,LDINC,LOADT,PLD IS',I13,3F8.3)
C
C     Shrinking the load vector and stiff matrix.
C
      DO 500 I=1,NT
      DO 500 M=1,IDF
        IF(I.EQ.L(M)) THEN
          D(M)=DLDINC(I)
          IF(NCONS.EQ.1) THEN
            EXLVC(M)=TXVC(I)
C             WRITE(6,*) M,' EXLVC IN ASSMB: ',EXLVC(M)
          END IF
          DO 510 J=1,NT
          DO 510 N=1,IDF
```

```
          IF(J.EQ.L(N)) THEN
            A(M,N)=TS(I,J)
          END IF
 510      CONTINUE
          IF(NDC.EQ.1) THEN
            DO 505 J=1,NT
             DO 505 N=1,JJD
               IF(J.EQ.LD(N)) THEN
                 AD(M,N)=TS(I,J)
               END IF
 505        CONTINUE
          END IF
        END IF
 500 CONTINUE
C
C
     IF(NDC.EQ.1) THEN
     DO 600 I=1,NT
      DO 600 M=1,JJD
       IF(I.EQ.LD(M)) THEN
         IF(NCONS.EQ.1) THEN
             DBVC(M)=TXVC(I)
C          WRITE(6,*) M,' EXLVC IN ASSMB: ',EXLVC(M)
         END IF
         DO 610 J=1,NT
         DO 610 N=1,IDF
         IF(J.EQ.L(N)) THEN
           ADD(M,N)=TS(I,J)
         END IF
 610     CONTINUE
           DO 605 J=1,NT
            DO 605 N=1,JJD
              IF(J.EQ.LD(N)) THEN
                ADC(M,N)=TS(I,J)
              END IF
 605       CONTINUE
       END IF
 600 CONTINUE
     END IF
C
C
     K=0
     DO 550 I=1,NEQT
       DO 550 J=1,NEQT
C          K=K+1
C          P(K)=A(I,J)
           STIFFN(I,J)=A(I,J)
 550 CONTINUE
C
C    Inverse the stiffness matrix
C
     IJOB=1
     DD1=1.0
C      CALL LINV3F(A,BB,IJOB,NEQT,NEQT,DD1,DD2,AINV,IER)
       CALL  LINRG(NEQT,A,NEQT,A,NEQT)
     DETMNT=DD1*(2**DD2)
     IF(IER.EQ.130) THEN
       WRITE(6,*) 'INVERSE PROB.
       STOP
     END IF
C
C    WRITE(6,*) 'END ASSEM'
     RETURN
     END
C     (END ASSEMBL)
C
```

```
C     Next subroutine is used to calculate the nodal force
C
      SUBROUTINE INTFRC(III,IEL,XX,YY,ZZ,VF,PD,PDL,PLD)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION XX(1),YY(1),ZZ(1),VF(NNODE,5),PD(1),PDL(1),PLD(1)
      DIMENSION H(2),P(2),R(8),S(8),X(8),Y(8),Z(8),ND(8),IEL(NELM,8),
     1                   VFE(40)
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /DIRCS/ IR60,IR61,IR62,IR63,IR64,IR65
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /A3/ CL1(8),CM1(8),CN1(8),CL2(8),CM2(8),CN2(8),
     1            CL3(8),CM3(8),CN3(8)
C
      DO 30 I=1,NT
        PLD(I)=0.0
   30 CONTINUE
C
      DO 700 I=1,NELM
        I1=IEL(I,1)
        I2=IEL(I,2)
        I3=IEL(I,3)
        I4=IEL(I,4)
        I5=IEL(I,5)
        I6=IEL(I,6)
        I7=IEL(I,7)
        I8=IEL(I,8)
C
C     Calculate the nodal force for each element
C
      CALL UPDATA(III,I,I1,I2,I3,I4,I5,I6,I7,I8,VR(IR1),VR(IR2),VR(IR3),
     1          VR(IR14),VR(IR22),VR(IR28),VR(IR60),VR(IR61),VR(IR62))
C
C
          DO 700 J=1,8
            DO 700 K=1,5
              JJ=IEL(I,J)*5-5+K
              J1=J*5-5+K
              PLD(JJ)=PLD(JJ)+PD(J1)
C             write(6,110) i,jj,j1
  700 CONTINUE
C
      RETURN
      END
C     (END INTFRC)
C
C     Subroutine CESM is used to calculate the stiffness matrix for
C     each element
C
      SUBROUTINE CESM(III,IL,I1,I2,I3,I4,I5,I6,
     1             I7,I8,SM,XX,YY,ZZ,VF,ESM,EXLD,GCL1,GCL2,GCL3)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
C
C
      DIMENSION XX(1),YY(1),ZZ(1),VF(NNODE,5),SM(40,40),ESM(40,40),
```

```
     1           H(2),P(2),R(8),S(8),X(8),Y(8),HH(4),PP(4),
     2           Z(8),ND(8),VFE(40),EXED(40),EXLD(40),
     3           GCL1(NNODE,3),GCL2(NNODE,3),GCL3(NNODE,3)
C
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /A3/ CL1(8),CM1(8),CN1(8),CL2(8),CM2(8),CN2(8),
     1           CL3(8),CM3(8),CN3(8)
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /DIRCS/ IR60,IR61,IR62,IR63,IR64,IR65
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
C
C
      ND(1)=11
      ND(2)=12
      ND(3)=13
      ND(4)=14
      ND(5)=15
      ND(6)=16
      ND(7)=17
      ND(8)=18
C
      CALL MNU(40,40,SM)
      DO 20 I=1,40
        EXLD(I)=0.0
   20 CONTINUE
C
      DO 250 I=1,8
        X(I)=XX(ND(I))
        Y(I)=YY(ND(I))
        Z(I)=ZZ(ND(I))
C      ( Change displacemet field from matrix to vector.)
C
        DO 250 J=1,5
          VFE(I*5-5+J)=VF(ND(I),J)
  250 CONTINUE
C
C
      R(1)=-1
      S(1)=-1
      R(2)=1
      S(2)=-1
      R(3)=1
      S(3)=1
      R(4)=-1
      S(4)=1
C
      R(5)=0
      S(5)=-1
      R(6)=1
      S(6)=0
      R(7)=0
      S(7)=1
      R(8)=-1
      S(8)=0
C     WRITE(6,157) IL
C
```

```
      DO 344 I=1,8
      CL1(I)=GCL1(ND(I),1)
      CM1(I)=GCL1(ND(I),2)
      CN1(I)=GCL1(ND(I),3)
      CL2(I)=GCL2(ND(I),1)
      CM2(I)=GCL2(ND(I),2)
      CN2(I)=GCL2(ND(I),3)
      CL3(I)=GCL3(ND(I),1)
      CM3(I)=GCL3(ND(I),2)
      CN3(I)=GCL3(ND(I),3)
C
  344 CONTINUE
  346 FORMAT(I12,9F7.4)
C
C
      H(1)=1.0
      H(2)=1.0
C
      P(1)=0.577352692
      P(2)=-P(1)
C
C     HH(1)=0.3478548451
C     HH(2)=H(1)
C     HH(3)=0.6521451548
C     HH(4)=H(3)
C     PP(1)=0.8611363115
C     PP(2)=-P(1)
C     PP(3)=0.3399810435
C     PP(4)=-P(3)
C
      DO 150 I=1,2
        DO 150 J=1,2
          DO 150 K=1,2
           U=P(I)
           V=P(J)
           W=P(K)
C
C     Calculate the stiffness matrix at every integration point
C
      CALL CB(III,IL,I,J,K,U,V,W,X,Y,Z,DETJ,VR(IR25),VR(IR28),
     1        VR(IR29),VR(IR30),VR(IR31),VR(IR32),VR(IR33),
     2        VR(IR34),VR(IR35),VR(IR36),VR(IR37),VR(IR38),
     3        VR(IR39),VR(IR40),VR(IR47),EXED,VR(IR53),VR(IR56),
     4        VR(IR57))
C
C
           DO 150 M=1,40
            IF(NCONS.EQ.1) THEN
              EXLD(M)=EXLD(M)+H(I)*H(J)*H(K)*EXED(M)*DETJ
            END IF
            DO 150 N=1,40
              SM(M,N)=SM(M,N)+H(I)*H(J)*H(K)*ESM(M,N)*DETJ
C
  150       CONTINUE
C
C       WRITE(6,*) 'DETJ=',DETJ
  154 FORMAT('M,N,SM(M,N) IS:',2I3,1F12.4)
C
      RETURN
      END
C
C
C     NEXT SUBROUTINE IS USED TO CALCULATE THE DIRECTION
C     COSINES AT NODE POINTS.HERE R,S,X,Y ARE THE NODE
C     COORD. IN REF.AND CART. COORD. RESPECTIVELY. CXR..
C     CZN ARE THE DIRECTION COSINES.
```

```
      SUBROUTINE CN(R,S,X,Y,Z,CXR,CYR,CZR,
     1              CXS,CYS,CZS,CXN,CYN,CZN)

      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION X(8),Y(8),Z(8),FR(8),FS(8)
C
C     XS.. MEANS DX/DS AND SO ON
      S2=S*S
      R2=R*R
C
C     WRITE(6,*) R,S
C     WRITE(6,*)
C     DO 20 I=1,8
C     WRITE(6,10) I,X(I),Y(I),Z(I)
C 20  CONTINUE
  10  FORMAT('X,Y,Z(I) ARE: ',I13,3F10.4)
C
      FR(1)=(2.0*R+S)*(1.0-S)/4.0
      FR(2)=(2.0*R-S)*(1.0-S)/4.0
      FR(3)=(2.0*R+S)*(1.0+S)/4.0
      FR(4)=(2.0*R-S)*(1.0+S)/4.0
      FR(5)=-R*(1.0-S)
      FR(6)=(1.0-S2)/2.0
      FR(7)=-R*(1.0+S)
      FR(8)=-(1.0-S2)/2.0
C
      FS(1)=(1.0-R)*(2.0*S+R)/4.0
      FS(2)=(1.0+R)*(2.0*S-R)/4.0
      FS(3)=(1.0+R)*(2.0*S+R)/4.0
      FS(4)=(1.0-R)*(2.0*S-R)/4.0
      FS(5)=-(1.0-R2)/2.0
      FS(6)=-(1.0+R)*S
      FS(7)=(1.0-R2)/2.0
      FS(8)=-(1.0-R)*S
C
      XR=0
      YR=0
      ZR=0
      XS=0
      YS=0
      ZS=0
C
      DO 315 I=1,8
       XR=XR+FR(I)*X(I)
       YR=YR+FR(I)*Y(I)
       ZR=ZR+FR(I)*Z(I)
       XS=XS+FS(I)*X(I)
       YS=YS+FS(I)*Y(I)
       ZS=ZS+FS(I)*Z(I)
 315  CONTINUE
C
C     GRR,GSS,GRS ARE THE METRIC TENSOR IN THE REFERENCE COORD.
C
      GRR=XR*XR+YR*YR+ZR*ZR
      GSS=XS*XS+YS*YS+ZS*ZS
      GRS=XR*XS+YR*YS+ZR*ZS
C
      GRRH=SQRT(GRR)
      GSSH=SQRT(GSS)
      GRSHH=GRRH*GSSH
C
C     WRITE(6,408) R,S,GRR,GSS,GRS
 408  FORMAT('THE METRIC AT NODE R= ',1F2.0,'S= ',1F2.0,3F10.5)
C     WRITE(6,409) R,S,GRRH,GSSH,GRSHH
```

```
  409 FORMAT('THE METRIC AT NODE R= ',1F2.0,'S= ',1F2.0,3F10.5)
C
C
C      CXR IS THE DIRECTION COSINE BETWEEN THE AXES X AND R.THE
C      SAME MEANING THROUGH CZS.
C
       CXR=XR/GRRH
       CYR=YR/GRRH
       CZR=ZR/GRRH
C
       CXS=XS/GSSH
       CYS=YS/GSSH
       CZS=ZS/GSSH
C
C
C      THE CXN..ARE THE DIRECTION COSINES BETWEEN THE UNIT NORMAL
C      AND THE COORD. X,Y,Z.
C
       CXN=(YR*ZS-ZR*YS)/GRSHH
       CYN=(ZR*XS-XR*ZS)/GRSHH
       CZN=(XR*YS-YR*XS)/GRSHH
C
       RETURN
       END
C
C
C
C      THIS IS A PROCEDURE TO MULTIPLY TWO MATRIX
C
       SUBROUTINE MMT(I,K,J,A1,A2,A)
       IMPLICIT REAL*8(A-H,O-Z)
       IMPLICIT INTEGER*8(I-N)
       DIMENSION A1(I,K),A2(K,J),A(I,J)
C
       CALL MNU(I,J,A)
       DO 20 M=1,I
         DO 20 N=1,J
           DO 20 L=1,K
             TEMP=A1(M,L)*A2(L,N)
             A(M,N)=A(M,N)+TEMP
   20  CONTINUE
       RETURN
       END
C
C      .
C      THIS IS A PROCEDURE TO MAKE NULL MATRIX
C
       SUBROUTINE MNU(I,J,A)
       IMPLICIT REAL*8(A-H,O-Z)
       IMPLICIT INTEGER*8(I-N)
       DIMENSION A(I,J)
       DO 30 M=1,I
        DO 30 N=1,J
          A(M,N)=0.0
   30  CONTINUE
       RETURN
       END
C
C      Subroutine transp is to make transpose matrix.
C
       SUBROUTINE TRANSP(I,J,XI,XO)
       IMPLICIT REAL*8(A-H,O-Z)
       IMPLICIT INTEGER*8(I-N)
       DIMENSION XI(I,J),XO(J,I)
C
       DO 10 M=1,I
```

```
      DO 10 N=1,J
         XO(N,M)=XI(M,N)
   10 CONTINUE
      RETURN
      END
```

Subroutine GetGeom(r,s,t,t0,x,y,z,rj,detj) is to calculate the geometric property at an intergration point. Here input is: r,s - the intergration position,t0 - the thickness of the the shell, the x,y,z - the nodes's coordinates.The Jacobin and the reversed Jacobin matrix,as well as the determinate of the Jacobin matrix are calculated. A,B,C,D,E,G are the outputs.

```
      SUBROUTINE GEOM(R,S,T,TO,X,Y,Z,DETJ,A,B,C,D,E,G)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION X(8),Y(8),Z(8),RJ(3,3),F(8),FR(8),FS(8),CJ(3,3),
     2          A(8),B(8),C(8),D(8),E(8),G(8)
      COMMON /A3/CL1(8),CM1(8),CN1(8),CL2(8),CM2(8),CN2(8),
     1           CL3(8),CM3(8),CN3(8)

      S2=S*S
      R2=R*R
      S3=S2*S
      R3=R2*R
C
C     F(k) is the shape function evaluated at node k.
C
      F(1)=(1.0-R)*(1.0-S)*(-R-S-1.0)/4.0
      F(2)=(1.0+R)*(1.0-S)*(R-S-1.0)/4.0
      F(3)=(1.0+R)*(1.0+S)*(R+S-1.0)/4.0
      F(4)=(1.0-R)*(1.0+S)*(-R+S-1.0)/4.0
      F(5)=(1.0-R2)*(1.0-S)/2.0
      F(6)=(1.0+R)*(1.0-S2)/2.0
      F(7)=(1.0-R2)*(1.0+S)/2.0
      F(8)=(1.0-R)*(1.0-S2)/2.0
C
C     FR(k) is the derivetive w.r.t. r of the shape function
C
      FR(1)=(2.0*R+S)*(1.0-S)/4.0
      FR(2)=(2.0*R-S)*(1.0-S)/4.0
      FR(3)=(2.0*R+S)*(1.0+S)/4.0
      FR(4)=(2.0*R-S)*(1.0+S)/4.0
      FR(5)=-R*(1.0-S)
      FR(6)=(1.0-S2)/2.0
      FR(7)=-R*(1.0+S)
      FR(8)=-(1.0-S2)/2.0
C
C     FR(k) is the derivetive w.r.t. s of the shape function
C
      FS(1)=(1.0-R)*(2.0*S+R)/4.0
      FS(2)=(1.0+R)*(2.0*S-R)/4.0
      FS(3)=(1.0+R)*(2.0*S+R)/4.0
      FS(4)=(1.0-R)*(2.0*S-R)/4.0
      FS(5)=-(1.0-R2)/2.0
      FS(6)=-(1.0+R)*S
      FS(7)=(1.0-R2)/2.0
      FS(8)=-(1.0-R)*S
C
C     CJ is the Jacobin matrix.
C
      CALL MNU(3,3,CJ)
C
      DO 346 I=1,8
        CJ(1,1)=CJ(1,1)+FR(I)*(X(I)+T*TO*CL3(I)/2.0)
        CJ(1,2)=CJ(1,2)+FR(I)*(Y(I)+T*TO*CM3(I)/2.0)
```

```
      CJ(1,3)=CJ(1,3)+FR(I)*(Z(I)+T*TO*CN3(I)/2.0)
      CJ(2,1)=CJ(2,1)+FS(I)*(X(I)+T*TO*CL3(I)/2.0)
      CJ(2,2)=CJ(2,2)+FS(I)*(Y(I)+T*TO*CM3(I)/2.0)
      CJ(2,3)=CJ(2,3)+FS(I)*(Z(I)+T*TO*CN3(I)/2.0)
      CJ(3,1)=F(I)*TO*CL3(I)/2.0+CJ(3,1)
      CJ(3,2)=F(I)*TO*CM3(I)/2.0+CJ(3,2)
      CJ(3,3)=F(I)*TO*CN3(I)/2.0+CJ(3,3)
  346 CONTINUE
C
C     Detj is the determinate of the Jacobin matrix.
C
      DETJ=CJ(1,1)*(CJ(2,2)*CJ(3,3)-CJ(3,2)*CJ(2,3))
     1     -CJ(1,2)*(CJ(2,1)*CJ(3,3)-CJ(3,1)*CJ(2,3))
     2     +CJ(1,3)*(CJ(2,1)*CJ(3,2)-CJ(3,1)*CJ(2,2))
C
C     WRITE(6,347) DETJ
C 347 FORMAT('DETJ IS',1F12.9)
C
C     RJ is the inverse of the jacobin matrix.
C
C
      RJ(1,1)=(CJ(2,2)*CJ(3,3)-CJ(3,2)*CJ(2,3))/DETJ
      RJ(1,2)=-(CJ(1,2)*CJ(3,3)-CJ(3,2)*CJ(1,3))/DETJ
      RJ(1,3)=(CJ(1,2)*CJ(2,3)-CJ(2,2)*CJ(1,3))/DETJ
C
      RJ(2,1)=-(CJ(2,1)*CJ(3,3)-CJ(3,1)*CJ(2,3))/DETJ
      RJ(2,2)=(CJ(1,1)*CJ(3,3)-CJ(3,1)*CJ(1,3))/DETJ
      RJ(2,3)=-(CJ(1,1)*CJ(2,3)-CJ(2,1)*CJ(1,3))/DETJ
C
      RJ(3,1)=(CJ(2,1)*CJ(3,2)-CJ(3,1)*CJ(2,2))/DETJ
      RJ(3,2)=-(CJ(1,1)*CJ(3,2)-CJ(3,1)*CJ(1,2))/DETJ
      RJ(3,3)=(CJ(1,1)*CJ(2,2)-CJ(2,1)*CJ(1,2))/DETJ
C
      DO 360 I=1,8
        A(I)=RJ(1,1)*FR(I)+RJ(1,2)*FS(I)
        B(I)=RJ(2,1)*FR(I)+RJ(2,2)*FS(I)
        C(I)=RJ(3,1)*FR(I)+RJ(3,2)*FS(I)
        D(I)=TO*(A(I)*T+RJ(1,3)*F(I))/2.0
        E(I)=TO*(B(I)*T+RJ(2,3)*F(I))/2.0
        G(I)=TO*(C(I)*T+RJ(3,3)*F(I))/2.0
  360 CONTINUE
C
      RETURN
      END
C
C     Subroutine Rotsmatrix is to get the rotate transformation matrix. Here
C     the input is r,s,x,y,z. Output is transformation matrix tl.
C
      SUBROUTINE ROTMTRX(R,S,X,Y,Z,TL)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION X(8),Y(8),Z(8),TL(6,6)
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
C
       CALL CN(R,S,X,Y,Z,PL1,PM1,PN1,PL2,PM2,PN2,PL3,PM3,PN3)
C
C     WRITE(6,*) 'PL1=',PL1,' PL2=',PL2,' PL3=',PL3
C     WRITE(6,*) 'PM1=',PM1,' PM2=',PM2,' PM3=',PM3
```

```
C     WRITE(6,*) 'PN1=',PN1,' PN2=',PN2,' PN3=',PN3
      TL(1,1)=PL1**2
      TL(2,1)=PL2**2
      TL(3,1)=PL3**2
      TL(4,1)=PL1*PL2*2.0
      TL(5,1)=PL2*PL3*2.0
      TL(6,1)=PL3*PL1*2.0
C
      TL(1,2)=PM1**2
      TL(2,2)=PM2**2
      TL(3,2)=PM3**2
      TL(4,2)=PM1*PM2*2.0
      TL(5,2)=PM2*PM3*2.0
      TL(6,2)=PM3*PM1*2.0
C
      TL(1,3)=PN1**2
      TL(2,3)=PN2**2
      TL(3,3)=PN3**2
      TL(4,3)=PN1*PN2*2.0
      TL(5,3)=PN2*PN3*2.0
      TL(6,3)=PN3*PN1*2.0
C
      TL(1,4)=PL1*PM1
      TL(2,4)=PL2*PM2
      TL(3,4)=PL3*PM3
      TL(4,4)=PL1*PM2+PL2*PM1
      TL(5,4)=PL2*PM3+PL3*PM2
      TL(6,4)=PL3*PM1+PL1*PM3
C
      TL(1,5)=PM1*PN1
      TL(2,5)=PM2*PN2
      TL(3,5)=PM3*PN3
      TL(4,5)=PM1*PN2+PM2*PN1
      TL(5,5)=PM2*PN3+PM3*PN2
      TL(6,5)=PM3*PN1+PM1*PN3
C
      TL(1,6)=PN1*PL1
      TL(2,6)=PN2*PL2
      TL(3,6)=PN3*PL3
      TL(4,6)=PN1*PL2+PN2*PL1
      TL(5,6)=PN2*PL3+PN3*PL2
      TL(6,6)=PN3*PL1+PN1*PL3
C
      RETURN
      END
C
C
C     Subroutine nonlm is to get the nonlinear part of the matrix B. Here
C     the input is the geometric parameters a,b,c,d,e,g and the direction
C     cosines.The parameter ss is the stress calculated in last iteration.
C     The output is the matrix bn1(40,40) and bn2(40,40)
C
      SUBROUTINE NONLM(A,B,C,D,E,G,SS,SS1,BN1,BN2,BN3,B1,B1T,TMPSS)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION A(8),B(8),C(8),D(8),E(8),G(8),SS(9,9),SS1(9,9),
     1          BN1(40,40),BN2(40,40),BN3(40,40),B1(9,40),
     2          B1T(40,9),TMPSS(40,9)
C
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
```

```
     5                 IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /A3/CL1(8),CM1(8),CN1(8),CL2(8),CM2(8),CN2(8),
     1           CL3(8),CM3(8),CN3(8)
C
C
      CALL MNU(9,40,B1)
C
C
      DO 413 I=1,8
        B1(1,I*5-4)=A(I)
        B1(2,I*5-4)=B(I)
        B1(3,I*5-4)=C(I)
C
        B1(4,I*5-3)=A(I)
        B1(5,I*5-3)=B(I)
        B1(6,I*5-3)=C(I)

        B1(7,I*5-2)=A(I)
        B1(8,I*5-2)=B(I)
        B1(9,I*5-2)=C(I)
C
        B1(1,I*5-1)=-D(I)*CL2(I)
        B1(2,I*5-1)=-E(I)*CL2(I)
        B1(3,I*5-1)=-G(I)*CL2(I)
        B1(4,I*5-1)=-D(I)*CM2(I)
        B1(5,I*5-1)=-E(I)*CM2(I)
        B1(6,I*5-1)=-G(I)*CM2(I)
        B1(7,I*5-1)=-D(I)*CN2(I)
        B1(8,I*5-1)=-E(I)*CN2(I)
        B1(9,I*5-1)=-G(I)*CN2(I)
C
        B1(1,I*5)=D(I)*CL1(I)
        B1(2,I*5)=E(I)*CL1(I)
        B1(3,I*5)=G(I)*CL1(I)
        B1(4,I*5)=D(I)*CM1(I)
        B1(5,I*5)=E(I)*CM1(I)
        B1(6,I*5)=G(I)*CM1(I)
        B1(7,I*5)=D(I)*CN1(I)
        B1(8,I*5)=E(I)*CN1(I)
        B1(9,I*5)=G(I)*CN1(I)
  413 CONTINUE
C
C
      DO 430 I=1,40
        DO 430 J=1,9
          B1T(I,J)=B1(J,I)
  430 CONTINUE
C
      CALL MMT(40,9,9,B1T,SS,TMPSS)
      CALL MMT(40,9,40,TMPSS,B1,BN1)
C
      CALL MMT(40,9,9,B1T,SS1,TMPSS)
      CALL MMT(40,9,40,TMPSS,B1,BN3)
C
C     B2=B1 NOW.
      CALL MNU(9,40,B1)
C
      DO 414 I=1,8
        B1(1,I*5-4)=A(I)
        B1(2,I*5-4)=B(I)/2.0
        B1(3,I*5-4)=C(I)/2.0
        B1(4,I*5-4)=B(I)/2.0
        B1(7,I*5-4)=C(I)/2.0
C
```

```
         B1(2,I*5-3)=A(I)/2.0
         B1(4,I*5-3)=A(I)/2.0
         B1(5,I*5-3)=B(I)
         B1(6,I*5-3)=C(I)/2.0
         B1(8,I*5-3)=C(I)/2.0
C
         B1(3,I*5-2)=A(I)/2.0
         B1(6,I*5-2)=B(I)/2.0
         B1(7,I*5-2)=A(I)/2.0
         B1(8,I*5-2)=B(I)/2.0
         B1(9,I*5-2)=C(I)
C
         B1(1,I*5-1)=-D(I)*CL2(I)
         B1(2,I*5-1)=-(E(I)*CL2(I)+D(I)*CM2(I))/2.0
         B1(3,I*5-1)=-(G(I)*CL2(I)+D(I)*CN2(I))/2.0
         B1(4,I*5-1)=-(E(I)*CL2(I)+D(I)*CM2(I))/2.0
         B1(5,I*5-1)=-E(I)*CM2(I)
         B1(6,I*5-1)=-(G(I)*CM2(I)+E(I)*CN2(I))/2.0
         B1(7,I*5-1)=-(G(I)*CL2(I)+D(I)*CN2(I))/2.0
         B1(8,I*5-1)=-(G(I)*CM2(I)+E(I)*CN2(I))/2.0
         B1(9,I*5-1)=-G(I)*CN2(I)
C
         B1(1,I*5)=D(I)*CL1(I)
         B1(2,I*5)=(E(I)*CL1(I)+D(I)*CM1(I))/2.0
         B1(3,I*5)=(G(I)*CL1(I)+D(I)*CN1(I))/2.0
         B1(4,I*5)=(E(I)*CL1(I)+D(I)*CM1(I))/2.0
         B1(5,I*5)=E(I)*CM1(I)
         B1(6,I*5)=(G(I)*CM1(I)+E(I)*CN1(I))/2.0
         B1(7,I*5)=(G(I)*CL1(I)+D(I)*CN1(I))/2.0
         B1(8,I*5)=(G(I)*CM1(I)+E(I)*CN1(I))/2.0
  414 CONTINUE
C
      DO 432 I=1,40
        DO 432 J=1,9
          B1T(I,J)=B1(J,I)
C         B2T(I,J)=B2(J,I)
  432 CONTINUE
C
C
      CALL MMT(40,9,9,B1T,SS,TMPSS)
      CALL MMT(40,9,40,TMPSS,B1,BN2)
C
C
      RETURN
      END
C     (end nonlm)
C
C
C     Subroutine ELSMTR is used to calculate the elastic matrix
C
      SUBROUTINE ELSMTR(EM)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION EM(6,6)
      COMMON /MTL/ E,EU
      U=EU
      CALL MNU(6,6,EM)
      EM(1,1)=E/(1.0-U*U)
C     WRITE(6,*) 'EM=',EM(1,1)
      EM(2,2)=EM(1,1)
      EM(3,3)=1.0
      EM(1,2)=E*U/(1.0-U*U)
      EM(2,1)=EM(1,2)
      EM(5,5)=E/2/(1+U)
      EM(4,4)=EM(5,5)
      EM(6,6)=EM(5,5)
```

```
      RETURN
      END
C     (end eismtr)
C
C     This procedure is used to calculate the nodal force in
C     every element
C
      SUBROUTINE UPDATA(III,IL,I1,I2,I3,I4,I5,I6,I7,I8,XX,YY,ZZ,
     1                  VF,PD,PDL,GCL1,GCL2,GCL3)

      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION XX(1),YY(1),ZZ(1),VF(NNODE,5),PD(1),PDL(1)
      DIMENSION H(2),P(2),R(8),S(8),X(8),Y(8),Z(8),ND(8),
     1          VFE(40),GCL1(NNODE,3),GCL2(NNODE,3),GCL3(NNODE,3),
     2          HH(4),PP(4)
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /DIRCS/ IR60,IR61,IR62,IR63,IR64,IR65
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
      COMMON /A3/ CL1(8),CM1(8),CN1(8),CL2(8),CM2(8),CN2(8),
     1            CL3(8),CM3(8),CN3(8)
C
C
      ND(1)=I1
      ND(2)=I2
      ND(3)=I3
      ND(4)=I4
      ND(5)=I5
      ND(6)=I6
      ND(7)=I7
      ND(8)=I8
C
      DO 250 I=1,8
        X(I)=XX(ND(I))
        Y(I)=YY(ND(I))
        Z(I)=ZZ(ND(I))
C       WRITE(6,260) I,X(I),Y(I),Z(I),ND(I)
        DO 250 J=1,5
          VFE(I*5-5+J)=VF(ND(I),J)
  250 CONTINUE
  260 FORMAT(1X,'THE COORDINATES OF NODE',I2,1X,'ARE:',3F12.8,I12)
C
C
      R(1)=-1
      S(1)=-1
      R(2)=1
      S(2)=-1
      R(3)=1
      S(3)=1
      R(4)=-1
      S(4)=1
C
      R(5)=0
      S(5)=-1
      R(6)=1
```

```
      S(6)=0
      R(7)=0
      S(7)=1
      R(8)=-1
      S(8)=0

      DO 344 I=1,8
        CL1(I)=GCL1(ND(I),1)
        CM1(I)=GCL1(ND(I),2)
        CN1(I)=GCL1(ND(I),3)
        CL2(I)=GCL2(ND(I),1)
        CM2(I)=GCL2(ND(I),2)
        CN2(I)=GCL2(ND(I),3)
        CL3(I)=GCL3(ND(I),1)
        CM3(I)=GCL3(ND(I),2)
        CN3(I)=GCL3(ND(I),3)
C
  344 CONTINUE
  346 FORMAT(I12,9F7.4)
C
      DO 348 I=1,40
        PD(I)=0.0
  348 CONTINUE
C
      H(1)=1.0
      H(2)=1.0
C     WRITE(6,*) SM(1,1),SM(2,2)
      P(1)=0.577352692
      P(2)=-P(1)
C
C     HH(1)=0.3478548451
C     HH(2)=H(1)
C     HH(3)=0.6521451548
C     HH(4)=H(3)
C     PP(1)=0.8611363115
C     PP(2)=-P(1)
C     PP(3)=0.3399810435
C     PP(4)=-P(3)
C
      DO 150 I=1,2
        DO 150 J=1,2
          DO 150 K=1,2
           U=P(I)
           V=P(J)
           W=P(K)
C     WRITE(6,157) IL
C
       CALL CBUPDT(III,IL,ND,I,J,K,U,V,W,X,Y,Z,VR(IR14),VR(IR28),
     1             DETJ,VR(IR31),VR(IR32),VR(IR33),VR(IR29),
     2             VR(IR37),VR(IR38),VR(IR36),VR(IR39),VR(IR40),
     3             VR(IR30),VR(IR20),VR(IR47),VR(IR54),VR(IR55),
     4             VR(IR57))
C
C
            DO 150 M=1,40
            PD(M)=PD(M)+H(I)*H(J)*H(K)*PDL(M)*DETJ
C           write(6,10) m,pdl(m),pdl(m),detj
C           WRITE(6,*) 'PD(M) ',PD(M)
  150 CONTINUE
C     DO 151 I=1,40
C      WRITE(6,*) 'PD(M) ',PD(I)
C 151 CONTINUE
C  10 format('integ.i,pdl(i),pd(i),DETJ is: ',1i3,3f13.5)
C
C     WRITE(6,153) DETJ
C  153 FORMAT('DETJ IS:',1F12.4)
```

```
C
C
      RETURN
      END
C      (end update)
C
C
      SUBROUTINE GETDT(IEL,ID,IID,NEQ,MX,NHLF,NN,MEQT,
     1                    XX,YY,ZZ,DD1,DD2)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
C
C     Subroutine GETDT is designed to read data from data file. The data
C     needed are:
C                 nelm: The numberr of elements in the structure.
C                 nnode: The number of node of the structure.
C                 nstep: The number of load step to be taken.
C                 ncrtr: The max. iterations to balance the node force.
C                 xx,yy,zz:  initial coordinates of the nodes
C                 iel(i,j):  The node name,here i is the element name
C                             and j is the node sequence in the local
C                             corordinate.
C                 id(i)  (i=5*nnode):  The the constrain for displacement
C                 iid(i,j):  The boundary constrain for displacement.
C                            here i--element j--generalized displacement.
C                 dd(i,j):  The load at node i corespond to the direction j.
C    Data calculated:
C                 NHBW:  the half-band-width of the problem.
C                 neqt:  The number of equation to be solved.
C
C
      DIMENSION IEL(NELM,8),ID(1),IID(NNODE,5),NEQ(NNODE,5),
     1          MX(1),NHLF(1),MN(1),MEQT(NELM,40)
      DIMENSION XX(1),YY(1),ZZ(1),DD1(1),DD2(1)
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /MTL/ E,EU
      COMMON /GEO/ TO
      COMMON /DISCT/ NDC,NDBC
      COMMON /OUTVR/ NPT,NPV
C
C
      WRITE(6,10) NELM
   10 FORMAT(' THE NUMBER OF ELEMENT IS: ',I13)
      WRITE(6,20) NNODE
   20 FORMAT(' THE NUMBER OF NODES IS: ',I15)
      WRITE(6,30) E,EU
   30 FORMAT(' THE MATERIAL CONSTANTS E AND NU ARE: ',2F13.3)
      WRITE(6,*) ' THE THICKNESS OF THE SHELL IS: ',TO
      DO 100 NODE=1,NNODE
        READ(5,*) KK,XX(NODE),YY(NODE),ZZ(NODE)
        WRITE(6,101) NODE,XX(NODE),YY(NODE),ZZ(NODE)
  100 CONTINUE
  101 FORMAT('  THE COORDINATES OF NODE ',I12,' IS: ',3F12.5)
C
C
```

```
      DO 106 I=1,NNODE
          READ(5,*) KK,(IID(I,J),J=1,5)
          WRITE(6,107) I,(IID(I,J),J=1,5)
C          WRITE(6,107) I,IID(I,1),IID(I,2),IID(I,3),
     1                  IID(I,4),IID(I,5)
 106  CONTINUE
 107  FORMAT('  THE CONSTRAIN AT NODE ',I13,' IS',5I3)
      NDBC=0
      DO 108 I=1,NNODE
        DO 108 J=1,5
          ID(I*5-5+J)=IID(I,J)
          IF(ID(I*5-5+J).EQ.2) NDBC=NDBC+1
 108    CONTINUE
      NDC=0
      IF(NDBC.NE.0) NDC=1
C
C     WRITE(6,*) 'The first group load is:'
C     DO 110 I=1,NNODE
C         READ(5,*) KK,(DD1(I*5-5+J),J=1,5)
C       K=I*5-5
C       WRITE(6,114) I,DD1(K+1),DD1(K+2),DD1(K+3),DD1(K+4),DD1(K+5)
C 110 CONTINUE
C
      WRITE(6,*) 'THE SECOND GROUP LOAD IS:'
      DO 112 I=1,NNODE
          READ(5,*) KK,(DD2(I*5-5+J),J=1,5)
        K=I*5-5
        WRITE(6,114) I,DD2(K+1),DD2(K+2),DD2(K+3),DD2(K+4),DD2(K+5)
 112  CONTINUE
 114  FORMAT('THE LOAD CORRESP. TO NODE ',I12,' IS: ',5F8.3)
C
      DO 122 I=1,NELM
          READ(5,*) KK,(IEL(I,J),J=1,8)
          WRITE(6,126) I,IEL(I,1),IEL(I,2),IEL(I,3),IEL(I,4),
     1                 IEL(I,5),IEL(I,6),IEL(I,7),IEL(I,8)
 122  CONTINUE
C
C       READ(15,*) NPT,NPV
 126  FORMAT('  THE NODE NUMBER FOR ELEMENT ',I12,' IS: ',8I4)
C
C     Next part is to calculate the half band width of the stiffness matrix.
C
C     For every unknown disp. get the correspond eqution number: NEL(I,J)
      K=1
      DO 200 I=1,NNODE
        DO 200 J=1,5
          IF(IID(I,J).EQ.1) THEN
            NEQ(I,J)=0
          ELSE
          IF(IID(I,J).EQ.0) THEN
            NEQ(I,J)=K
            K=K+1
          END IF
          END IF
 200  CONTINUE
       NEQT=K-1
       WRITE (6,400) NEQT
 400  FORMAT('THE NUMBER OF EQUATIONS IS: ',I16)
C
C     CALL MNU(NELM,40,MEQT)
C
C     Get all the equation number in element i : MEQT(I,K)  (k=1..40) here.
C
C     DO 240 I=1,NELM
C       K=1
C       DO 240 J=1,8
```

```
C         DO 240 M=1,5
C           MEQT(I,K)=NEQ(IEL(I,J),M)
C           WRITE(6,500) I,K,MEQT(I,K)
C           K=K+1
C 240 CONTINUE
C
  500 FORMAT('THE EQ. NUMBER IN ELM(I) (K=1..40) IS: ',3I6)
C     DO 600 K=1,40
C      WRITE(6,515) K,MEQT(1,K)
C 600 CONTINUE
C 515 FORMAT('THE MEQT(1,K) IS:',2I5)
C
C     Get the max and min eq. number in an element. The difference is the
C     half-band-width of the stiffness matrix in the element
C
C     DO 280 I=1,NELM
C       MX(I)=0
C       MN(I)=NT
C       DO 300 K=1,40
C         IF(MEQT(I,K).GT.MX(I)) THEN
C            MX(I)=MEQT(I,K)
C            WRITE(6,490) I,K,MEQT(I,K),MX(I)
C 490        FORMAT('I,K,MEQT(I,K),MX(I):',4I5)
C         END IF
C         IF((MEQT(I,K).GT.0).AND.(MEQT(I,K).LT.MN(I))) THEN
C           MN(I)=MEQT(I,K)
C         END IF
C 300   CONTINUE
C       NHLF(I)=MX(I)-MN(I)
C       WRITE(6,460) I,MX(I),MN(I),NHLF(I)
C 280 CONTINUE
C 460 FORMAT('The max,min and half band width in el(i) is: ',4i5)
C
C     Get the half-band-width of the stiffness matrix of the structure
C
C     NHBW=0
C     DO 320 I=1,NELM
C       IF(NHLF(I).GT.NHBW) NHBW=NHLF(I)
C 320 CONTINUE
C
C      WRITE(6,440) NHBW
  440 FORMAT('THE HALF-BAND-WIDTH OF THE STIFFNESS MATRIX IS: ',I15)
      RETURN
      END
C
C
      SUBROUTINE CRITR1(II,ND,D,FRCINC,ACTFRC,DDD,VLIMN,ICNC1,VALS)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
C
C     Subroutine CRITRI is to build an exit criteria for the equilibrium
C     iterations.
C     input:
C     ii = The ii'th number iteration
C     DLDINC = The load increament
C     DLOADT = Te load level at that iteration.
C     PLD = The node force in last iteration
C     DVEC = The unknown solved in last iteration
C     VLINIT = the criteria value calculated in the first iteration.
C     Output:
C     ICONCL = The conclusion : Exit the loop or not.
C              1 = exit
C              0 = Keep inside the loop.
C
      DIMENSION D(1),FRCINC(1),ACTFRC(1),DDD(1)
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
```

```
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /ITESCH/ ROOT,DTLAM,SGN,IPP,TROOT,ASO,SP
      COMMON /DISCT/ NDC,NDBC
C
C

      AINS=0.0
      COEFF=90.0
      VLIMNO=VLIMN
      VAL=0.0
      IF(II.EQ.1) THEN
        VLIMN=0.0
        DO 10 I=1,ND
C             IF(NDC.EQ.0) THEN
               TEMP=D(I)*ROOT-FRCINC(I)
C             ELSE
C               TEMP=DDD(I)*ROOT-FRCINC(I)
C             END IF
C            AINS=AINS+TEMP
            VLIMN=VLIMN+TEMP*TEMP
            IF(I.LT.11) THEN
            WRITE(6,90) II,I,D(I)*ROOT,FRCINC(I),ACTFRC(I)
            END IF
C          WRITE(6,80) II,I,D(I)*ROOT,FRCINC(I),TEMP,VAL
C   80     FORMAT('II,I,D(I),FRCINC,TEMP: ',2I4,4F12.3)
   10   CONTINUE
        VLIMN=SQRT(VLIMN)
        VAL=VLIMN
        WRITE(6,*) 'VAL=',VAL
       ELSE
         DO 20 I=1,ND
C             IF(NDC.EQ.0) THEN
               TEMP=D(I)*ROOT-FRCINC(I)
C             ELSE
C               TEMP=DDD(I)*ROOT-FRCINC(I)
C             END IF
            VAL=VAL+TEMP*TEMP
C           AINS=AINS+TEMP
C          IF ((I.EQ.2).OR.(I.EQ.7)) THEN
           IF (I.LT.10) THEN
            WRITE(6,90) II,I,D(I)*ROOT,FRCINC(I),ACTFRC(I)
           END IF
   90      FORMAT('II,I,D(I),FRCINC,ACTF: ',2I4,3F14.6)
   20    CONTINUE
         VAL=SQRT(VAL)
       END IF
C      WRITE(6,*) 'AINS ',AINS
C
      ICNC1=0
      VALS=VAL*COEFF
      IF(VLIMN.GT.10.0) VLIMN=10.0
      IF(NDC.EQ.1.AND.VLIMN.LT.0.005) ICNC1=1
      IF(VALS.LT.VLIMNO) ICNC1=1
       WRITE(6,50) VAL*COEFF,VLIMN,ICNC1
   50 FORMAT('VAL1,CRIT1,CONCL ARE: ',2F14.4,I13)
C
      RETURN
```

```
      END
      SUBROUTINE CRITR3(II,ND,D,FRCINC,ACTFRC,DDD,VLIMN,ICNCl,VALS)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
C
C     Subroutine CRITR3 is to build an exit criteria for the equilibrium
C     iterations
C     input:
C     ii = The ii'th number iteration
C     DLDINC = The load increament
C     DLOADT = Te load level at that iteration.
C     PLD = The node force in last iteration
C     DVEC = The unknown solved in last iteration
C     VLINIT = the criteria value calculated in the first iteration.
C     Output:
C     ICONCL = The conclusion : Exit the loop or not.
C              1 = exit
C              0 = Keep inside the loop.
C
      DIMENSION D(1),FRCINC(1),ACTFRC(1),DDD(1)
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
C
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /ITESCH/ ROOT,DTLAM,SGN,IPP,TROOT,ASO,SP
      COMMON /DISCT/ NDC,NDBC
C
C

      AINS=0.0
      COEFF=50.0
      ZR=0.0
      VLIMNO=VLIMN
      VAL=0.0
      IF(II.EQ.1) THEN
        VLIMN=0.0
        DO 10 I=1,ND
C            IF(NDC.EQ.0) THEN
              TEMP=-FRCINC(I)
C            ELSE
C              TEMP=DDD(I)*ROOT-FRCINC(I)
C            END IF
C          AINS=AINS+TEMP
           VLIMN=VLIMN+TEMP*TEMP
           IF(I.LT.11) THEN
           WRITE(6,90)  II,I,ZR,FRCINC(I),ACTFRC(I)
           END IF
C         WRITE(6,80)  II,I,D(I)*ROOT,FRCINC(I),TEMP,VAL
C 80     FORMAT('II,I,D(I),FRCINC,TEMP: ',2I4,4F12.3)
  10    CONTINUE
        VLIMN=SQRT(VLIMN)
        VAL=VLIMN
        WRITE(6,*)  'VAL=',VAL
       ELSE
         DO 20 I=1,ND
C            IF(NDC.EQ.0) THEN
              TEMP=-FRCINC(I)
```

```
C           ELSE
C             TEMP=DDD(I)*ROOT-FRCINC(I)
C           END IF
          VAL=VAL+TEMP*TEMP
C         AINS=AINS+TEMP
C         IF  ((I.EQ.2).OR.(I.EQ.7)) THEN
          IF  (I.LT.10) THEN
          WRITE(6,90)  II,I,ZR,FRCINC(I),ACTFRC(I)
          END IF
   90     FORMAT('II,I,D(I),FRCINC,ACTF: ',2I4,3F14.6)
   20    CONTINUE
         VAL=SQRT(VAL)
       END IF
      ICNC1=0
      VALS=VAL*COEFF
      IF(VLIMN.GT.10.0) VLIMN=10.0
      IF(NDC.EQ.1.AND.VLIMN.LT.0.005)  ICNC1=1
      IF(VALS.LT.VLIMNO)  ICNC1=1
       WRITE(6,50)  VAL*COEFF,VLIMN,ICNC1
   50 FORMAT('VAL1,CRIT1,CONCL ARE: ',2F14.4,I13)
C
      RETURN
      END
C
C
      SUBROUTINE CMPT1
C
C     CMPT1 is used to make a initial arangement of
C     the real and integer vector.
C     The parameters are :
C             NEIM    -- The number of elements in the shell.
C             NNODE   -- The number of nodes in the shell.
C             NT      -- NNODE*5
C             ND      -- The number of unknown displacements.
C             NO      -- 2*nd
C             NSTEP   -- Number of load steps.
C
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      CHARACTER TITLE*80
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /MTL/ E,EU
      COMMON /LNGTHI/ LI1,LI2,LI3,LI4,LI5,LI6,LI7,LI8,LI9,LI10
      COMMON /LNGTHR/ LR1,LT2,LR3,LR4,LR5,LR6,LR7,LR8,LR9,LR10,
     1                LR11,LR12,LR13,LR14,LR15,LR16,LR17,LR18,
     2                LR19,LR20,LR21,LR22,LR23,LR24,LR25,LR26
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /GEO/ TO
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
      COMMON /BOD/ DO,ZCO,ZC1,ZC2,ZC3,ZM1,ZM2,CA1,CA2,CR1,CR2,ZNO
      COMMON /WAL/ WK,WB,WN2,WN3,WN4,WN5,WN6,WN8,WN9,WN10,WN11,WRO
      COMMON /SQ/ SQQ
      COMMON /DISCT/ NDC,NDBC
      COMMON /CREEP/ ICRP,NBCRP,NBDN,CRPTM,IPON
```

```
      COMMON /CRPC/ CRPC1,CRPC2
      COMMON /TMPEF/ IDO,NTEM,NITR,NANM,CEXPN,TMMIN,TMINC,TMMAX,TMPP
      COMMON /OUTVR/ NPT,NPV

      READ(5,*) NELM,NNODE,NSTEP,ITRLM,E,EU,TO,COEF1,COEF2,FACTOR,
     1          NSHOW1,NSHOW2,NSHOW3,INSIDT,KPDT,DTLM1,SQQ
C      WRITE(6,20) NELM,NNODE
   20 FORMAT('THE NUMBER OF ELEMENTS IS:',I13,' THE NUMBER OF NODE IS:'
     1        ,I14)
C
      READ(5,*) IDO,NTEM,NITR,NANM,CEXPN,TMMIN,TMINC,TMMAX
      READ(5,*) NCONS,MODEL,ETAA,TDELT
      TINIT=TDELT
      READ(5,*) ICRP,NBCRP
      READ(5,*) NPT,NPV
      CRPC1=1.0
      CRPC2=1.0
      IF(NCONS.EQ.0.AND.ICRP.EQ.1) THEN
       WRITE(6,*) 'ELASTIC MODEL CAN NOT BE USED TO CALCULATE CREEP.
     1             STOP'
       STOP
      END IF
C     MODEL=1..BODNER, MODEL=2..WALKER
C      READ(5,*) DO,ZCO,ZC1,ZC2,ZC3,ZM1,ZM2,CA1,CA2,CR1,CR2,ZNO
C      READ(5,*) WK,WB,WN2,WN3,WN4,WN5,WN6,WN8,WN9,WN10,WN11,WRO
      NE8=NELM*8
      ND3=NNODE*3
      ND5=NNODE*5
      NT=ND5
      ND5S=ND5*ND5
C
      LI1=NE8
      LI2=ND5
      LI3=ND5
      LI4=ND5
      LI5=ND5
      LI6=NELM
      LI7=NELM
      LI8=NELM*40
      LI9=NDBC
      LI10=NDBC
C
      LR1=NNODE
      LR2=NNODE
      LR3=NNODE
      LR4=ND5
      LR5=ND5
      LR6=ND5
      LR7=NSTEP
C
      IP1=1
      IP2=IP1+LI1
      IP3=IP2+LI2
      IP4=IP3+LI3
      IP5=IP4+LI4
      IP6=IP5+LI5
      IP7=IP6+LI6
      IP8=IP7+LI7
      IP9=IP8+LI8
      IP10=IP9+LI9
      IP11=IP10+LI10
      WRITE(6,*) 'NUMBER OF INTEGER:',IP11
C
      IR1=1
      IR2=IR1+LR1
      IR3=IR2+LR2
```

```
      IR4=IR3+LR3
      IR5=IR4+LR4
      IR6=IR5+LR5
      IR7=IR6+LR6
      IR8=IR7+LR7
C
      RETURN
      END
C
C
C     CMPT2 is used to make a mamory arangement of
C     the real and integer vector.
C
      SUBROUTINE CMPT2
C
C     The parameters are :
C             NELM   -- The number of elements in the shell.
C             NNODE  -- The number of nodes in the shell.
C             NT     -- NNode*5
C             ND     -- The number of unknown displacements.
C             NO     -- 2*nd
C             NSTEP  -- Number of load steps.
C
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      CHARACTER TITLE*80
C
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /MTL/ E,EU
      COMMON /LNGTHI/ LI1,LI2,LI3,LI4,LI5,LI6,LI7,LI8,LI9,LI10
      COMMON /LNGTHR/ LR1,LT2,LR3,LR4,LR5,LR6,LR7,LR8,LR9,LR10,
     1                LR11,LR12,LR13,LR14,LR15,LR16,LR17,LR18,
     2                LR19,LR20,LR21,LR22,LR23,LR24,LR25,LR26
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /DIRCS/ IR60,IR61,IR62,IR63,IR64,IR65
      COMMON /DISCT/ NDC,NDBC
      COMMON /DISVC/ IR66,IR67,IR68,IR69
      COMMON /DISV1/ IR70,IR71,IR72,IR73,IR74,IR75
C
C
      NE8=NELM*8
      ND3=NNODE*3
      ND5=NNODE*5
      NT=ND5
      ND5S=ND5*ND5
C
      LI1=NE8
      LI2=ND5
      LI3=ND5
      LI4=ND5
      LI5=ND5
      LI6=NELM
      LI7=NELM
      LI8=NELM*40
C
```

```
      LR8=NEQT
      LR9=ND5
      LR10=ND5
      LR11=ND5
      LR12=ND5
      LR13=ND5
      LR14=ND5
      LR15=ND5
      LR16=ND5
      LR17=NEQT
      LR18=ND5
      LR19=ND5S
      LR20=NELM*72
      LR21=1600
      LR22=40
C      LR23=NEQT*(NEQT+1)/2
      LR23=1
C     LR23 is for P(I), if use skylight, then active it.
      LR24=NEQT*NEQT
      LR25=1600
      LR26=ND5
      LR27=ND5
      LR28=1600
      LR29=1600
      LR30=1600
      LR31=360
      LR32=360
      LR33=360
      LR34=81
      LR35=81
      LR36=36
      LR37=36
      LR38=36
      LR39=36
      LR40=36
      LR41=1
C     LR41=LR23
      LR42=ND5
      LR43=NNODE
      LR44=NNODE
      LR45=NNODE
      LR46=ND5
      LR47=NELM*72
      LR48=ND5
      LR49=ND5
      LR50=ND5
      LR51=NELM*96
C     2*2*2*12=96  FOR BOTH BODNER AND WALKER'S MODEL
C     64=2*2*2*(6+1)  6=BETA(I,J) 7=Zi  (THE STATE VARIABLE FOR
C     BODNER'S MODEL
      LR52=ND5
      LR53=6
      LR54=NELM*8*24*6
      LR55=NELM*8*24
      LR56=NELM*8*6
      LR57=NELM*8*36
      LR58=NELM*8*12
      LR59=ND5
      LR60=NNODE*3
      LR61=NNODE*3
      LR62=NNODE*3
      LR63=NNODE*3
      LR64=NNODE*3
      LR65=NNODE*3
      LR66=NDBC*NDBC
      LR67=NDBC*NEQT
```

```
LR68=LR67
LR69=NDBC
LR70=NDBC
LR71=NDBC
LR72=NDBC
LR73=NDBC
LR74=NDBC
LR75=NDBC

IP1=1
IP2=IP1+L11
IP3=IP2+L12
IP4=IP3+L13
IP5=IP4+L14
IP6=IP5+L16
IP7=IP6+L17
IP8=IP5+L15
IP9=IP8+L18
C
IR9=IR8+LR8
IR10=IR9+LR9
IR11=IR10+LR10
IR12=IR11+LR11
IR13=IR12+LR12
IR14=IR13+LR13
IR15=IR14+LR14
IR16=IR15+LR15
IR17=IR16+LR16
IR18=IR17+LR17
IR19=IR18+LR18
IR20=IR19+LR19
IR21=IR20+LR20
IR22=IR21+LR21
IR23=IR22+LR22
IR24=IR23+LR23
IR25=IR24+LR24
IR26=IR25+LR25
IR27=IR26+LR26
IR28=IR27+LR27
IR29=IR28+LR28
IR30=IR29+LR29
IR31=IR30+LR30
IR32=IR31+LR31
IR33=IR32+LR32
IR34=IR33+LR33
IR35=IR34+LR34
IR36=IR35+LR35
IR37=IR36+LR36
IR38=IR37+LR37
IR39=IR38+LR38
IR40=IR39+LR39
IR41=IR40+LR40
IR42=IR41+LR41
IR43=IR42+LR42
IR44=IR43+LR43
IR45=IR44+LR44
IR46=IR45+LR45
IR47=IR46+LR46
IR48=IR47+LR47
IR49=IR48+LR48
IR50=IR49+LR49
IR51=IR50+LR50
IR52=IR51+LR51
IR53=IR52+LR52
IR54=IR53+LR53
IR55=IR54+LR54
```

```
      IR56=IR55+LR55
      IR57=IR56+LR56
      IR58=IR57+LR57
      IR59=IR58+LR58
      IR60=IR59+LR59
      IR61=IR60+LR60
      IR62=IR61+LR61
      IR63=IR62+LR62
      IR64=IR63+LR63
      IR65=IR64+LR64
      IR66=IR65+LR65
      IR67=IR66+LR66
      IR68=IR67+LR67
      IR69=IR68+LR68
      IR70=IR69+LR69
      IR71=IR70+LR70
      IR72=IR71+LR71
      IR73=IR72+LR72
      IR74=IR73+LR73
      IR75=IR74+LR74
C
      WRITE(6,*) 'INTEGER=',IP9
      MEMOR=IR75+LR75
      IF(MEMOR.LT.MAXR) THEN
      WRITE(6,*) 'THE PREDIFINED MEMORY IS NOT ENOUGH.'
      WRITE(6,*) 'MEMORY: ',MEMOR
      STOP
      END IF
      WRITE(6,*) 'MEMORY: ',MEMOR
C     IF (MEMOR.GT.100) STOP
C
      RETURN
      END
C
C
C*****************************************************************************
C    Subroutine Bolsul is the solution phase using Bodner's constitutive
C    equation.
C    Inputs are:
C    BL  used to find the local strain.
C    VFE the displace increament. epsln=bl.vfe
C    SVT3D and SVBLD are the data calculated in the processing face.
C    State variable BETA(..7)(1..6-directional, 7-isotropic) are updated.
C    The derivative of the state variables STVDF and the derivative of the
C    nonlinear strain EPSND are calculated.
C    The stress increament is also calculated.
C*****************************************************************************
C
C     CALL BODSUL(IL,II,JJ,KK,VR(IR31),VR(IR29),VR(IR54),
C    1             VR(IR55),VR(IR51),SD,VR(IR56),VR(IR57))
C
      SUBROUTINE BODSUL(IAA,IA,IB,IC,BL,VFE,SVT3D,SVBLD,BETA,SD,
     1                  BDSV,EM4,AA)
C
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION BL(6,40),VFE(1),SVT3D(NELM,2,2,2,144),TMVEC(24),
     1          SVBLD(NELM,2,2,2,24),BETA(NELM,2,2,2,12),SD(6,1),
     2          BDSV(NELM,2,2,2,6),EM4(NELM,2,2,2,36),
     3          DLBET(6),TMV(19),AA(6,1)
C
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
```

```
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /ITESCH/ ROOT,DTLAM,SGN,IPP,TROOT,ASO,SP
      COMMON /GEO/ TO
      COMMON /CNTRL/ DETMNT
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /BOD/ DO,ZCO,ZC1,ZC2,ZC3,ZM1,ZM2,CA1,CA2,CR1,CR2,ZNO
      COMMON /CREEP/ ICRP,NBCRP,NBDN,CRPTM,IPON
C
      IPR=0
      IF((IA.EQ.1).AND.(IB.EQ.1).AND.(IC.EQ.1)) IPR=1
C
C
  59  FORMAT(6F12.4)
C     if(ipr.eq.1) then
C     do 220 i=1,19
C       write(6,59) (-svt3d(iaa,ia,ib,ic,i*6-6+j),j=1,6)
C220  continue
C     end if
      DO 80 I=1,19
        TMVEC(I)=0.0
        DO 80 J=1,6
          TMVEC(I)=TMVEC(I)-SVT3D(IAA,IA,IB,IC,I*6-6+J)*AA(J,1)
  80    CONTINUE
C     if(ipr.eq.1) write(6,*) ' vbld, tmv, tmvec in FACE2: '
      DO 60 I=1,19
          TMV(I)=TMVEC(I)
        TMVEC(I)=SVBLD(IAA,IA,IB,IC,I)+TMVEC(I)
C     IF(IPR.EQ.1)  then
C     write(6,*) I,' ',svbld(iaa,ia,ib,ic,i),'  ',TMV(I),'  ',tmvec(i)
C     end if
  60  CONTINUE
C
      DO 100 I=1,6
        SD(I,1)=TMVEC(I)
        DLBET(I)=TMVEC(I+13)
C        WRITE(6,*)  I,' D(Zd/DT): ',STVDF(IAA,IA,IB,IC,I)
 100  CONTINUE
C
C      IF(IPR.EQ.1) THEN
C      WRITE(6,*) 'PUELAS:'
C      WRITE(6,8)  (TMV(I),I=1,6)
C      WRITE(6,8)  (SD(I,1),I=1,6)
C  8   FORMAT(6F12.8)
C      END IF
C
      DO 120 I=1,6
        BETA(IAA,IA,IB,IC,I)=BETA(IAA,IA,IB,IC,I)+DLBET(I)
        IF(BETA(IAA,IA,IB,IC,I).GT.ZC3) BETA(IAA,IA,IB,IC,I)=ZC3
        IF(BETA(IAA,IA,IB,IC,I).LT.-ZC3) BETA(IAA,IA,IB,IC,I)=-ZC3
C        WRITE(6,*) I,' BETA: ',BETA(IAA,IA,IB,IC,I)
 120  CONTINUE
      BETA(IAA,IA,IB,IC,7)=BETA(IAA,IA,IB,IC,7)+TMVEC(13)
      IF(BETA(IAA,IA,IB,IC,7).GT.ZC1) BETA(IAA,IA,IB,IC,7)=ZC1
      IF(BETA(IAA,IA,IB,IC,7).LT.(2.0*ZCO-ZC1)) BETA(IAA,IA,IB,IC,7)=
     1    2.0*ZCO-ZC1
C     if(ipr.eq.1)  WRITE(6,*) '8 =Zi BETA: ',BETA(IAA,IA,IB,IC,7)
C
```

```
C     STVDF(1) is the dirivative of the undirectional variable.
C     BETA(7) is the undirectional variable.
C
      RETURN
      END
C     END(BODSOL)
C
C
C *********************************************************************
C *  Subroutine Bodner is to prepare the stiffness matrix and the     *
C *  residure force. Input is the state variable and current stress.  *
C *  Output is EM2 (to form stiffness matrix by cb), BDLD             *
C *  (to form the force term by cb), SVT3D and SVBLD (will be used    *
C *  in the sulution face)                                            *
C *********************************************************************
C
C
      SUBROUTINE BODNER(III,IAA,IA,IB,IC,SIG,ZZZ,EM2,S,BETA,BDLD,
     1             SVT3D,SVBLD,ZZR,BDSV,EM4,AINV)
C
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION SIG(3,3),ZZZ(19,19),EM2(6,6),S(3,3),BETA(NELM,2,2,2,12),
     1          BDLD(1),SVT3D(NELM,2,2,2,144),SVBLD(NELM,2,2,2,24),
     2          ZZR(19,6),VEC1(19),VCTL(19),GA(19),BETAA(7),AINV(1),
     3          VEPS(6),SS(6),SECTM(6),T3D(19,6),VEPSLN(3,3),
     4          BDSV(NELM,2,2,2,6),EM4(NELM,2,2,2,36),SIGVC(6)
     5          ,AAA(6,6),BBB(6,6),CCC(6,6),DDD(6,6),VECC(19)
C
      COMMON /BOD/ DO,ZCO,ZC1,ZC2,ZC3,ZM1,ZM2,CA1,CA2,CR1,CR2,ZNO
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
C
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /ITESCH/ ROOT,DTLAM,SGN,IPP,TROOT,ASO,SP
      COMMON /GEO/ TO
      COMMON /CNTRL/ DETMNT
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
      COMMON /ABDFST/ ISEC
      COMMON /NCTT/ NCT(12,2,2,2)
      COMMON /NMBITR/ NUM
C
C
C     ZNO,DO are input constants in kinematical equation.
C
C     ACS,ZC1,ZC2,ZC3,CM1,CM2,CR1,CR2 are constants in state variable equations.
C     S(i,j) is the stress deviator
C     DJ2=1/2*S(I,J)*S(I,J)
C     SJ2=SIG(I,J)*SIG(I,J)
C     ZV1=Zi
C     SIGM(6)---SIG(3,3)  ...........
C     VSTV=D(Z)/DT
C     VSTV1=D(ZV1)/DT
C
C     ET=-ETA*TDELT   where eta and deltat are given.
```

```
C
      IPR=0
      IF((IA.EQ.1).AND.(IB.EQ.1).AND.(IC.EQ.1))  IPR=1
C
      DO 20 I=1,7
        BETAA(I)=BETA(IAA,IA,IB,IC,I)
   20 CONTINUE
C     WRITE(6,*)  'NUM=',NUM
      IF((NUM.EQ.1.OR.NUM.EQ.2).AND.(INSIDT.NE.1)) THEN
        BETA(IAA,IA,IB,IC,7)=ZCO
        ZV1=ZCO
      ELSE
        ZV1=BETA(IAA,IA,IB,IC,7)
      END IF
C
      ET=-ETAA*TDELT
C
      SAV=(SIG(1,1)+SIG(2,2)+SIG(3,3))/3.0
C
C      IF(IPR.EQ.1) THEN
C      WRITE(6,*) 'SIGMA IN BODNER'
C      DO 80 I=1,3
C        WRITE(6,32)  (SIG(I,J),J=1,3)
C  80  CONTINUE
C  32  FORMAT(3F12.4)
C      END IF
C
      DO 90 I=1,3
        DO 90 J=1,3
          IF(I.EQ.J) THEN
            S(I,J)=SIG(I,J)-SAV
          ELSE
            S(I,J)=SIG(I,J)
          END IF
   90 CONTINUE
C
      DJ2=0.0
      SJ2=0.0
C
      DO 100 I=1,3
        DO 100 J=1,3
          DJ2=DJ2+0.5*S(I,J)*S(I,J)
          SJ2=SJ2+SIG(I,J)*SIG(I,J)
  100 CONTINUE
      IF(IPR.EQ.1)  WRITE(6,*) 'DJ2,SJ2 IS: ',DJ2,SJ2
C
C     ZZ is state variable. ZZ=Zi+Zd
C     Now calculate ZD and ZZ
C
      ZD=0.0
      ZD=SIG(1,1)*BETAA(1)+SIG(2,2)*BETAA(2)+SIG(3,3)*BETAA(3)
     1   +2*(SIG(1,2)*BETAA(4)+SIG(2,3)*BETAA(5)+SIG(1,3)*BETAA(6))
      ZD=ZD/SJ2**0.5
      ZZ=ZV1+ZD
      ZZ2=ZZ*ZZ
      IF(IPR.EQ.1) THEN
      WRITE(6,*)  'STATE VAR ZI,ZD,ZZ ',ZV1,ZD,ZZ
      END IF
C
C     WRITE(6,*)  'CONTTOL VAR: ',0.5*(ZZ2/DJ2/3.0)**ZNO
      IF((0.5*(ZZ2/DJ2/3.0)**ZNO).GT.60) THEN
        FAC1=0.0
      ELSE
C       WRITE(6,*)  'COMMING'
        FAC1=DO*(EXP(-0.5*(ZZ2/DJ2/3.0)**ZNO))/DJ2**0.5
      END IF
```

```
      DO 40 I=1,3
        DO 40 J=1,3
          VEPSLN(I,J)=S(I,J)*FAC1
 40   CONTINUE
C
      VEPS(1)=VEPSLN(1,1)
      VEPS(2)=VEPSLN(2,2)
      VEPS(3)=VEPSLN(3,3)
      VEPS(4)=VEPSLN(1,2)
      VEPS(5)=VEPSLN(2,3)
      VEPS(6)=VEPSLN(1,3)

      NCT(IAA,IA,IB,IC)=1
C
C      if(ipr.eq.1) then
C       write(11,*)
C      end if
C      write(11,253)  (veps(i),i=1,6)
 253  FORMAT(6F12.10)
      VEPSLN(1,1)=VEPS(1)
      VEPSLN(2,2)=VEPS(2)
      VEPSLN(3,3)=VEPS(3)
      VEPSLN(1,2)=VEPS(4)
      VEPSLN(2,3)=VEPS(5)
      VEPSLN(1,3)=VEPS(6)
C
      SS(1)=S(1,1)
      SS(2)=S(2,2)
      SS(3)=S(3,3)
      SS(4)=S(1,2)
      SS(5)=S(2,3)
      SS(6)=S(1,3)
C
      SIGVC(1)=SIG(1,1)
      SIGVC(2)=SIG(2,2)
      SIGVC(3)=SIG(3,3)
      SIGVC(4)=SIG(1,2)
      SIGVC(5)=SIG(2,3)
      SIGVC(6)=SIG(1,3)
C
      FAC1=FAC1*ET
C     Now -eta*deltat is included in the formula in first 6*6 matrix.
C
      FAC2=ZZ2*ZNO*(ZZ2/DJ2/3.0)**(ZNO-1.0)/6.0/DJ2/DJ2-0.5/DJ2
      FAC3=FAC1*FAC2
      FAC4=-FAC1*ZNO*(1/3.0/DJ2)**ZNO*(ABS(ZZ)**(2.0*ZNO-1.0))
      IF(ZZ.GT.0.0) THEN
        FAC4=FAC4
      ELSE
        FAC4=-FAC4
      END IF
C
      FAC5=FAC4/(SJ2)**0.5
C
      CALL MNU(19,19,ZZZ)
C
      ZZZ(7,1)=FAC1*(2.0/3.0+S(1,1)*S(1,1)*FAC2)
      ZZZ(7,2)=FAC1*(-1.0/3.0+S(1,1)*S(2,2)*FAC2)
      ZZZ(7,3)=FAC1*(-1.0/3.0+S(1,1)*S(3,3)*FAC2)
      ZZZ(7,4)=FAC3*S(1,1)*S(1,2)
      ZZZ(7,5)=FAC3*S(1,1)*S(2,3)
      ZZZ(7,6)=FAC3*S(1,1)*S(1,3)
C
      ZZZ(8,1)=FAC1*(-1.0/3.0+S(2,2)*S(1,1)*FAC2)
      ZZZ(8,2)=FAC1*(2.0/3.0+S(2,2)*S(2,2)*FAC2)
```

```
      ZZZ(8,3)=FAC1*(-1.0/3.0+S(2,2)*S(3,3)*FAC2)
      ZZZ(8,4)=FAC3*S(2,2)*S(1,2)
      ZZZ(8,5)=FAC3*S(2,2)*S(2,3)
      ZZZ(8,6)=FAC3*S(2,2)*S(1,3)
C
      ZZZ(9,1)=FAC1*(-1.0/3.0+S(3,3)*S(1,1)*FAC2)
      ZZZ(9,2)=FAC1*(-1.0/3.0+S(3,3)*S(2,2)*FAC2)
      ZZZ(9,3)=FAC1*(2.0/3.0+S(3,3)*S(3,3)*FAC2)
      ZZZ(9,4)=FAC3*S(3,3)*S(1,2)
      ZZZ(9,5)=FAC3*S(3,3)*S(2,3)
      ZZZ(9,6)=FAC3*S(3,3)*S(1,3)
C
      ZZZ(10,1)=FAC3*S(1,2)*S(1,1)
      ZZZ(10,2)=FAC3*S(1,2)*S(2,2)
      ZZZ(10,3)=FAC3*S(1,2)*S(3,3)
      ZZZ(10,4)=FAC1*(1+S(1,2)*S(1,2)*FAC2)
      ZZZ(10,5)=FAC3*S(1,2)*S(2,3)
      ZZZ(10,6)=FAC3*S(1,2)*S(1,3)
C
      ZZZ(11,1)=FAC3*S(2,3)*S(1,1)
      ZZZ(11,2)=FAC3*S(2,3)*S(2,2)
      ZZZ(11,3)=FAC3*S(2,3)*S(3,3)
      ZZZ(11,4)=FAC3*S(2,3)*S(1,2)
      ZZZ(11,5)=FAC1*(1+S(2,3)*S(2,3)*FAC2)
      ZZZ(11,6)=FAC3*S(2,3)*S(1,3)
C
      ZZZ(12,1)=FAC3*S(1,3)*S(1,1)
      ZZZ(12,2)=FAC3*S(1,3)*S(2,2)
      ZZZ(12,3)=FAC3*S(1,3)*S(3,3)
      ZZZ(12,4)=FAC3*S(1,3)*S(1,2)
      ZZZ(12,5)=FAC3*S(1,3)*S(2,3)
      ZZZ(12,6)=FAC1*(1.0+S(1,3)*S(1,3)*FAC2)
C
      ZZZ(7,7)=1.0
      ZZZ(8,8)=1.0
      ZZZ(9,9)=1.0
      ZZZ(10,10)=1.0
      ZZZ(11,11)=1.0
      ZZZ(12,12)=1.0
C
      ZZZ(7,13)=FAC4*S(1,1)
      ZZZ(8,13)=FAC4*S(2,2)
      ZZZ(9,13)=FAC4*S(3,3)
      ZZZ(10,13)=FAC4*S(1,2)
      ZZZ(11,13)=FAC4*S(2,3)
      ZZZ(12,13)=FAC4*S(1,3)
C
      ZZZ(7,14)=FAC5*S(1,1)*SIG(1,1)
      ZZZ(8,14)=FAC5*S(2,2)*SIG(1,1)
      ZZZ(9,14)=FAC5*S(3,3)*SIG(1,1)
      ZZZ(10,14)=FAC5*S(1,2)*SIG(1,1)
      ZZZ(11,14)=FAC5*S(2,3)*SIG(1,1)
      ZZZ(12,14)=FAC5*S(1,3)*SIG(1,1)
C
      ZZZ(7,15)=FAC5*S(1,1)*SIG(2,2)
      ZZZ(8,15)=FAC5*S(2,2)*SIG(2,2)
      ZZZ(9,15)=FAC5*S(3,3)*SIG(2,2)
      ZZZ(10,15)=FAC5*S(1,2)*SIG(2,2)
      ZZZ(11,15)=FAC5*S(2,3)*SIG(2,2)
      ZZZ(12,15)=FAC5*S(1,3)*SIG(2,2)
C
      ZZZ(7,16)=FAC5*S(1,1)*SIG(3,3)
      ZZZ(8,16)=FAC5*S(2,2)*SIG(3,3)
      ZZZ(9,16)=FAC5*S(3,3)*SIG(3,3)
      ZZZ(10,16)=FAC5*S(1,2)*SIG(3,3)
      ZZZ(11,16)=FAC5*S(2,3)*SIG(3,3)
```

```
      ZZZ(12,16)=FAC5*S(1,3)*SIG(3,3)
C
      ZZZ(7,17)=FAC5*S(1,1)*SIG(1,2)
      ZZZ(8,17)=FAC5*S(2,2)*SIG(1,2)
      ZZZ(9,17)=FAC5*S(3,3)*SIG(1,2)
      ZZZ(10,17)=FAC5*S(1,2)*SIG(1,2)
      ZZZ(11,17)=FAC5*S(2,3)*SIG(1,2)
      ZZZ(12,17)=FAC5*S(1,3)*SIG(1,2)
C
      ZZZ(7,18)=FAC5*S(1,1)*SIG(2,3)
      ZZZ(8,18)=FAC5*S(2,2)*SIG(2,3)
      ZZZ(9,18)=FAC5*S(3,3)*SIG(2,3)
      ZZZ(10,18)=FAC5*S(1,2)*SIG(2,3)
      ZZZ(11,18)=FAC5*S(2,3)*SIG(2,3)
      ZZZ(12,18)=FAC5*S(1,3)*SIG(2,3)
C
      ZZZ(7,19)=FAC5*S(1,1)*SIG(1,3)
      ZZZ(8,19)=FAC5*S(2,2)*SIG(1,3)
      ZZZ(9,19)=FAC5*S(3,3)*SIG(1,3)
      ZZZ(10,19)=FAC5*S(1,2)*SIG(1,3)
      ZZZ(11,19)=FAC5*S(2,3)*SIG(1,3)
      ZZZ(12,19)=FAC5*S(1,3)*SIG(1,3)
C
C     Next part is -[G,epslon n]
C
      PWR=0.0
      DO 150 I=1,3
        DO 150 J=1,3
          PWR=PWR+SIG(I,J)*VEPSLN(I,J)
  150 CONTINUE
C     WRITE(6,*) 'PLASTIC WORK IS: ',PWR
C
C     Row 13 is for state variable Zi.
C
      FAC6=-ZM1*(ZC1-ZV1)
C     IF(IPR.EQ.1) THEN
C      WRITE(6,*) 'FAC1: ',FAC1
C      WRITE(6,*) 'FAC2: ',FAC2
C      WRITE(6,*) 'FAC3: ',FAC3
C      WRITE(6,*) 'FAC4: ',FAC4
C      WRITE(6,*) 'FAC5: ',FAC5
C      WRITE(6,*) 'FAC6: ',FAC6
C     END IF
      ZZZ(13,7)=FAC6*SIG(1,1)
      ZZZ(13,8)=FAC6*SIG(2,2)
      ZZZ(13,9)=FAC6*SIG(3,3)
      ZZZ(13,10)=FAC6*SIG(1,2)*0.5
      ZZZ(13,11)=FAC6*SIG(2,3)*0.5
      ZZZ(13,12)=FAC6*SIG(1,3)*0.5
C
        ZZZ(13,13)=1.0+ET*(-ZM1*PWR-CA1*CR1*
     1           (ABS(((ZV1-ZC2)/ZC1))**(CR1-1.0)))
C
C     Row 8..13 are for state variable Zd or BETAij.
C     The order for BETAij is as stress or strain: 11,22,33,12,23,13.
C
      FAC7=ZC3/SJ2**0.5
C     WRITE(6,*) 'FAC7 ',FAC7
C
      FAC8=-ZM2*(FAC7*SIG(1,1)-BETAA(1))
      ZZZ(14,7)=FAC8*SIG(1,1)
      ZZZ(14,8)=FAC8*SIG(2,2)
      ZZZ(14,9)=FAC8*SIG(3,3)
      ZZZ(14,10)=FAC8*SIG(1,2)*0.5
      ZZZ(14,11)=FAC8*SIG(2,3)*0.5
      ZZZ(14,12)=FAC8*SIG(1,3)*0.5
```

```
C
      FAC8=-ZM2*(FAC7*SIG(2,2)-BETAA(2))
C
      ZZZ(15,7)=FAC8*SIG(1,1)
      ZZZ(15,8)=FAC8*SIG(2,2)
      ZZZ(15,9)=FAC8*SIG(3,3)
      ZZZ(15,10)=FAC8*SIG(1,2)*0.5
      ZZZ(15,11)=FAC8*SIG(2,3)*0.5
      ZZZ(15,12)=FAC8*SIG(1,3)*0.5
C
      FAC8=-ZM2*(FAC7*SIG(3,3)-BETAA(3))
C
      ZZZ(16,7)=FAC8*SIG(1,1)
      ZZZ(16,8)=FAC8*SIG(2,2)
      ZZZ(16,9)=FAC8*SIG(3,3)
      ZZZ(16,10)=FAC8*SIG(1,2)*0.5
      ZZZ(16,11)=FAC8*SIG(2,3)*0.5
      ZZZ(16,12)=FAC8*SIG(1,3)*0.5
C
      FAC8=-ZM2*(FAC7*SIG(1,2)-BETAA(4))
C
      ZZZ(17,7)=FAC8*SIG(1,1)
      ZZZ(17,8)=FAC8*SIG(2,2)
      ZZZ(17,9)=FAC8*SIG(3,3)
      ZZZ(17,10)=FAC8*SIG(1,2)*0.5
      ZZZ(17,11)=FAC8*SIG(2,3)*0.5
      ZZZ(17,12)=FAC8*SIG(1,3)*0.5
C
      FAC8=-ZM2*(FAC7*SIG(2,3)-BETAA(5))
C
      ZZZ(18,7)=FAC8*SIG(1,1)
      ZZZ(18,8)=FAC8*SIG(2,2)
      ZZZ(18,9)=FAC8*SIG(3,3)
      ZZZ(18,10)=FAC8*SIG(1,2)*0.5
      ZZZ(18,11)=FAC8*SIG(2,3)*0.5
      ZZZ(18,12)=FAC8*SIG(1,3)*0.5
C
      FAC8=-ZM2*(FAC7*SIG(1,3)-BETAA(6))
C
      ZZZ(19,7)=FAC8*SIG(1,1)
      ZZZ(19,8)=FAC8*SIG(2,2)
      ZZZ(19,9)=FAC8*SIG(3,3)
      ZZZ(19,10)=FAC8*SIG(1,2)*0.5
      ZZZ(19,11)=FAC8*SIG(2,3)*0.5
      ZZZ(19,12)=FAC8*SIG(1,3)*0.5
C
      RBT=0.0
C
      DO 160 I=1,3
        RBT=RBT+BETAA(I)*BETAA(I)
  160 CONTINUE
      DO 170 I=4,6
        RBT=RBT+2*BETAA(I)*BETAA(I)
  170 CONTINUE
C
C
      FAC9=-ET*CA2*(ZC1**(1.0-CR2))*(RBT**((CR2-1.0)/2.0))
      IF(ABS(RBT).LT.0.0000000001) THEN
        FAC10=0.0
      ELSE
        FAC10=FAC9*(CR2-1.0)/RBT
      END IF
C
C     WRITE(6,*) 'FAC9: ',FAC9,' FAC10: ',FAC10
      EPT=-ET*PWR*ZM2
C
```

```
      ZZZ(14,14)=FAC10*BETAA(1)*BETAA(1)+1.0+FAC9+EPT
      ZZZ(14,15)=FAC10*BETAA(1)*BETAA(2)
      ZZZ(14,16)=FAC10*BETAA(1)*BETAA(3)
      ZZZ(14,17)=FAC10*BETAA(1)*BETAA(4)
      ZZZ(14,18)=FAC10*BETAA(1)*BETAA(5)
      ZZZ(14,19)=FAC10*BETAA(1)*BETAA(6)
C
      ZZZ(15,14)=FAC10*BETAA(2)*BETAA(1)
      ZZZ(15,15)=FAC10*BETAA(2)*BETAA(2)+1.0+FAC9+EPT
      ZZZ(15,16)=FAC10*BETAA(2)*BETAA(3)
      ZZZ(15,17)=FAC10*BETAA(2)*BETAA(4)
      ZZZ(15,18)=FAC10*BETAA(2)*BETAA(5)
      ZZZ(15,19)=FAC10*BETAA(2)*BETAA(6)
C
      ZZZ(16,14)=FAC10*BETAA(3)*BETAA(1)
      ZZZ(16,15)=FAC10*BETAA(3)*BETAA(2)
      ZZZ(16,16)=FAC10*BETAA(3)*BETAA(3)+1.0+FAC9+EPT
      ZZZ(16,17)=FAC10*BETAA(3)*BETAA(4)
      ZZZ(16,18)=FAC10*BETAA(3)*BETAA(5)
      ZZZ(16,19)=FAC10*BETAA(3)*BETAA(6)
C
      ZZZ(17,14)=FAC10*BETAA(4)*BETAA(1)
      ZZZ(17,15)=FAC10*BETAA(4)*BETAA(2)
      ZZZ(17,16)=FAC10*BETAA(4)*BETAA(3)
      ZZZ(17,17)=FAC10*BETAA(4)*BETAA(3)+1.0+FAC9+EPT
      ZZZ(17,18)=FAC10*BETAA(4)*BETAA(5)
      ZZZ(17,19)=FAC10*BETAA(4)*BETAA(6)
C
      ZZZ(18,14)=FAC10*BETAA(5)*BETAA(1)
      ZZZ(18,15)=FAC10*BETAA(5)*BETAA(2)
      ZZZ(18,16)=FAC10*BETAA(5)*BETAA(3)
      ZZZ(18,17)=FAC10*BETAA(5)*BETAA(4)
      ZZZ(18,18)=FAC10*BETAA(5)*BETAA(5)+1.0+FAC9+EPT
      ZZZ(18,19)=FAC10*BETAA(5)*BETAA(6)
C
      ZZZ(19,14)=FAC10*BETAA(6)*BETAA(1)
      ZZZ(19,15)=FAC10*BETAA(6)*BETAA(2)
      ZZZ(19,16)=FAC10*BETAA(6)*BETAA(3)
      ZZZ(19,17)=FAC10*BETAA(6)*BETAA(4)
      ZZZ(19,18)=FAC10*BETAA(6)*BETAA(5)
      ZZZ(19,19)=FAC10*BETAA(6)*BETAA(6)+1.0+FAC9+EPT
C
C     Equation Zi+BETA(I,J)*U(I,J)=Z in increamental form.
C
C     ZZZ(14,13)=1.0
C
C     SJR=1.0/SJ2**0.5
C
C
      ZZZ(1,1)=1.0
      ZZZ(2,2)=1.0
      ZZZ(3,3)=1.0
      ZZZ(4,4)=1.0
      ZZZ(5,5)=1.0
      ZZZ(6,6)=1.0
C
      DO 333 I=1,6
        DO 333 J=1,6
          ZZZ(I,J+6)=EM2(I,J)
  333 CONTINUE
C
C
C     Now the matrix [zzz] is formed.
C     Next step is to find vector part.
C
C
```

```
C     VCTL(1..6) is the difference of d(epslon)/dt and f.
C
      DO 200 I=1,6
        VEC1(I+6)=TDELT*VEPS(I)
  200 CONTINUE
C
C     SECTM(i) is (G,epslon*d(epslon)/dt)
C
      DO 220 I=1,7
        SECTM(I)=0.0
        DO 220 J=1,6
          ZZZ(I+12,J+6)=0.0
          SECTM(I)=SECTM(I)+ZZZ(I+12,J+6)*VEPS(J)
C         SECTM(I)=SECTM(I)+ZZZ(I+12,J+6)*EPSND(IAA,IA,IB,IC,J)
  220 CONTINUE
C
C       IF(IPR.EQ.1) THEN
C        WRITE(6,*) 'VEPS:'
C        WRITE(6,211). (VEPS(I),I=1,6)
C        DO 210 I=1,7
C        WRITE(6,211)  (ZZZ(I+12,J+6),J=1,6)
C  210   CONTINUE
C  211   FORMAT(6F13.4)
C      WRITE(6,*) 'PWR=',PWR
C       END IF
C     GA is the state variable g.
C
        GA(1)=ZM1*(ZC1-ZV1)*PWR-CA1*ZC1*ABS(((ZV1-ZC2)/ZC1))**CR1
C     IF(IPR.EQ.1) THEN
C       WRITE(6,*) 'ZM1=',ZM1,' ZC1=',ZC1,' ZV1=',ZV1
C       WRITE(6,*) 'ZM2=',ZM2,' ZC3=',ZC3
C     END IF
C        WRITE(6,*) 'GA(1)=Zi: ',GA(1)
      DO 240 I=1,6
      GA(I+1)=ZM2*(ZC3*SIGVC(I)/SJ2**0.5-BETAA(I))*PWR+FAC9*BETAA(I)/ET
  240 CONTINUE
C
C     VCTL(7..13) is the difference between the derivative of the
C
      DO 280 I=1,7
        VEC1(I+12)=TDELT*(GA(I)+SECTM(I))
C       IF(IPR.EQ.1) WRITE(6,*) I,' SEC=',SECTM(I),' GA=',GA(I)
 280  CONTINUE
C
      DO 300 I=1,6
        VEC1(I)=0.0
  300 CONTINUE
C
      CALL MNU(19,6,ZZR)
      DO 180 I=1,6
        IF(ABS(BETAA(I)).GT.(ZC3-1.0)) THEN
          DO 190 J=1,190
            ZZZ(I+13,J)=0.0
  190     CONTINUE
          ZZZ(I+13,I+13)=1.0
          VEC1(I+13)=0.0
        END IF
  180 CONTINUE
C
      IF(BETAA(7).GT.(ZC1-1.0).OR.BETAA(7).LT.(2.0*ZC0-ZC1+1.0)) THEN
        DO 191 I=1,19
          ZZZ(13,I)=0.0
  191   CONTINUE
        ZZZ(13,13)=1.0
        VEC1(13)=0.0
      END IF
```

```
C
      DO 370 I=1,6
        DO 370 J=1,6
          ZZR(I,J)=-EM2(I,J)
  370 CONTINUE
C
C     ZZR=-D*
C
      IJOB=3
      IBOD=19
      DD1=1.0
C
C
       CALL  LINRG(IBOD,ZZZ,IBOD,ZZZ,IBOD)
       DO 978 I=1,IBOD
       VECC(I)=0.0
       DO 978 J=1,IBOD
         VECC(I)=ZZZ(I,J)*VEC1(J)+VECC(I)
  978  CONTINUE
       DO 972 I=1,IBOD
       VEC1(I)=VECC(I)
  972  CONTINUE
C
C       For cyber:
C       CALL LINV3F(ZZZ,VEC1,IJOB,IBOD,IBOD,DD1,DD2,AINV,IER)
C
      DETMNT=DD1*(2**DD2)
C      WRITE(6,*) 'The determinant of bodner matrix is: ',DETMNT
C
      IF(IER.EQ.130) THEN
        WRITE(6,*) 'INVERSE PROBLEM IN BODNER MATRIX, STOP.'
        STOP
      END IF
C
      CALL MMT(19,19,6,ZZZ,ZZR,T3D)
C      IF(IPR.EQ.1) THEN
C      write(6,*) 'element=',iaa
C      write(6,*) 'em2:'
C      DO 940 I=1,6
C        WRITE(6,970) (EM2(I,J),J=1,6)
C 940 CONTINUE
C      END IF
C
      DO 360 I=1,6
        DO 360 J=1,6
          EM2(I,J)=-T3D(I,J)
          EM4(IAA,IA,IB,IC,I*6-6+J)=EM2(I,J)
  360 CONTINUE
C       IF (IPR.EQ.1) THEN
C     write(6,*) 'TDELT=',tdelt
C      DO 980 I=1,6
C      WRITE(6,970) (EM2(I,J),J=1,6)
C        WRITE(6,970) (-T3D(I,J),J=1,6)
C 980 CONTINUE
C      END IF
  970 FORMAT(6F12.1)
C
      DO 380 I=1,6
        BDLD(I)=-VEC1(I)
        BDSV(IAA,IA,IB,IC,I)=BDLD(I)
C       IF(IPR.EQ.1) WRITE(6,*) 'BDLD(I):=',BDLD(I)
  380 CONTINUE
C
C  EM2 and BDLD will be back to subroutine cb for assemble.
C
      DO 400 I=1,19
```

```
          SVBLD(IAA,IA,IB,IC,I)=VEC1(I)
  400 CONTINUE
C
C     WRITE(6,*) 'T3D IN BODNER'
      DO 420 I=1,19
        DO 422 J=1,6
          SVT3D(IAA,IA,IB,IC,I*6-6+J)=T3D(I,J)
  422   CONTINUE
C     WRITE(6,423) (T3D(I,K),K=1,6)
  420 CONTINUE
C
      RETURN
      END
C
C     END BODNER
C
C*******************************************************************************
C    Subroutine walsul is the solution phase using Walker's constitutive
C    equation.
C    Input:
C    BL-  used to find the local strain.
C    VFE- the displace increament. epsln=bl.vfe
C    SVT3D and SVBLD are the data calculated in the processing face.
C    State variable BETA(..12) are updated.
C    The derivative of the statevariable STVDF and the derivative of the
C    nonlinear strain EPSND are calculated.
C*********************************************************************************
C
C
       SUBROUTINE WALSUL(IAA,IA,IB,IC,BL,VFE,SVT3D,SVBLD,BETA,SD,
     1                    BDSV,EM4,AA)
C
       IMPLICIT REAL*8(A-H,O-Z)
       IMPLICIT INTEGER*8(I-N)
       DIMENSION BL(6,40),VFE(1),SVT3D(NELM,2,2,2,144),TMVEC(24),
     1           SVBLD(NELM,2,2,2,24),BETA(NELM,2,2,2,12),SD(6,1),
     2           BDSV(NELM,2,2,2,6),EM4(NELM,2,2,2,36),
     3           DBTA1(6),DBTA2(6),AA(6,1)
C
       COMMON /SCHALR1/ NELM,NNODE,NT
       COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                  NSHOW3,HRZ,ITRLM,FACTOR
       COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
       COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                 IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                 IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                 IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                 IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                 IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
       COMMON /RLVEC/ VR(1)
       COMMON /INTVEC/ IPT(1)
       COMMON /ITESCH/ ROOT,DTLAM,SGN,IPP,TROOT,ASO,SP
       COMMON /GEO/ TO
       COMMON /CNTRL/ DETMNT
       COMMON /CONTN/ INSIDT,KPDT,DTLM1
       COMMON /WAL/ WK,WB,WN2,WN3,WN4,WN5,WN6,WN8,WN9,WN10,WN11,WRO
       COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
       COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
       COMMON /WKLMT/ WAL1,WAL2
C
       IPR=0
       IF((IA.EQ.1).AND.(IB.EQ.1).AND.(IC.EQ.1)) IPR=1
C      WRITE(6,*) 'IAA= ',IAA,' IA..IC ',IA,IB,IC
C      WRITE(6,*) 'WHERE CHANGED IN BODSUL'
C      DO 52 I=1,19
C        WRITE(6,53) (SVT3D(1,1,1,1,I*6-6+J),J=1,6)
```

```
C 52  CONTINUE
  53  FORMAT(6F12.4)
  59  FORMAT(6F12.4)
      DO 60 I=1,24
        TMVEC(I)=0.0
        DO 80 J=1,6
          TMVEC(I)=TMVEC(I)-SVT3D(IAA,IA,IB,IC,I*6-6+J)*AA(J,1)
  80    CONTINUE
        TMVEC(I)=SVBLD(IAA,IA,IB,IC,I)+TMVEC(I)
        IF(IPR.EQ.1) THEN
         WRITE(6,*) I,' TMVEC(I) IN SOLFACE: ',TMVEC(I)
        END IF
  60  CONTINUE

      DO 100 I=1,6
        SD(I,1)=TMVEC(I)
        DBTA1(I)=TMVEC(I+12)
        DBTA2(I)=TMVEC(I+18)
C        WRITE(6,*)   I,' D(Zd/DT): ',STVDF(IAA,IA,IB,IC,I)
 100  CONTINUE
C

      DO 120 I=1,6
       BETA(IAA,IA,IB,IC,I)=BETA(IAA,IA,IB,IC,I)+DBTA1(I)
       BETA(IAA,IA,IB,IC,I+6)=BETA(IAA,IA,IB,IC,I+6)+DBTA2(I)
        IF(BETA(IAA,IA,IB,IC,I).GT.WAL1) BETA(IAA,IA,IB,IC,I)=WAL1
        IF(BETA(IAA,IA,IB,IC,I).LT.-WAL1) BETA(IAA,IA,IB,IC,I)=-WAL1
        IF(BETA(IAA,IA,IB,IC,I+6).GT.WAL2) BETA(IAA,IA,IB,IC,I+6)=WAL2
        IF(BETA(IAA,IA,IB,IC,I+6).LT.-WAL1) BETA(IAA,IA,IB,IC,I+6)=-WAL2
C       if (ipr.eq.1) then
C       write(6,*) i, ' dta1=',dbta1(i),' dbta2=',dbta2(i)
C       WRITE(6,*) I,' BA1: ',BETA(IAA,IA,IB,IC,I),
C     1              ' ba2=',beta(iaa,ia,ib,ic,i+6)
C       end if
 120  CONTINUE
C
      RETURN
      END
C     END(WALSOL)
C
C ***********************************************************************
C *  Subroutine WALKER is to prepare the stiffness matrix and the       *
C *  residure force. Input is the state variable and current stress.    *
C *  Output is EM2 (to form stiffness matrix by cb), BDLD               *
C *  (to form the force term by cb), SVT3D and SVBLD (will be used      *
C *  in the sulution face)                                               *
C ***********************************************************************
C
      SUBROUTINE WALKER(III,IAA,IA,IB,IC,SIG,ZZZ,EM2,S,BETA,BDLD,
     1           SVT3D,SVBLD,ZZR,BDSV,EM4,AINV)
C
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION SIG(3,3),ZZZ(24,24),EM2(6,6),S(3,3),BETA(NELM,2,2,2,12),
     1          BDLD(1),SVT3D(NELM,2,2,2,144),SVBLD(NELM,2,2,2,24),
     2          ZZR(24,6),VEC1(24),VCTL(24),GA(24),BETAA(6),AINV(1),
     3          VEPS(6),SS(6),SECTM(12),T3D(24,6),VEPSLN(3,3),
     4          BDSV(NELM,2,2,2,6),EM4(NELM,2,2,2,36),SIGVC(6)
     5          ,AAA(6,6),BBB(6,6),CCC(6,6),DDD(6,6),BTA1(6),BTA2(6)
     6          ,DEFW(6),SGNW(6),VECC(24)
C
      COMMON /WAL/ WK,WB,WN2,WN3,WN4,WN5,WN6,WN8,WN9,WN10,WN11,WRO
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
```

```
     1                   NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /ITESCH/ ROOT,DTLAM,SGN,IPP,TROOT,ASO,SP
      COMMON /GEO/ TO
      COMMON /CNTRL/ DETMNT
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
      COMMON /ABDFST/ ISEC
      COMMON /WKLMT/ WAL1,WAL2
      COMMON /NCTT/ NCT(12,2,2,2)
C
C     ZNO,DO are input constants in kinematical equation.
C
C     ACS,ZC1,ZC2,ZC3,CM1,CM2 are constants in state variable equations.
C     CR1,CR2  AS WELL.
C     S(i,j) is the stress deviator
C     DJ2=1/2*S(I,J)*S(I,J)
C     SJ2=SIG(I,J)*SIG(I,J)
C     ZV1=Zi
C     SIGM(6)---SIG(3,3)  ...........
C     VSTV=D(Z)/DT
C     VSTV1=D(ZV1)/DT
C
C     ET=-ETA*TDELT   where eta and deltat are given.
C
      IPR=0
      IF((IA.EQ.1).AND.(IB.EQ.1).AND.(IC.EQ.1)) IPR=1
      DO 20 I=1,6
        BTA1(I)=BETA(IAA,IA,IB,IC,I)
        BTA2(I)=BETA(IAA,IA,IB,IC,I+6)
   20 CONTINUE
C
      DO 30 I=1,6
        BETAA(I)=BTA1(I)+BTA2(I)
   30 CONTINUE
C
      ET=-ETAA*TDELT
C
      SAV=(SIG(1,1)+SIG(2,2)+SIG(3,3))/3.0
C
      DO 90 I=1,3
        DO 90 J=1,3
          IF(I.EQ.J) THEN
            S(I,J)=SIG(I,J)-SAV
          ELSE
            S(I,J)=SIG(I,J)
          END IF
   90 CONTINUE
C
      SS(1)=S(1,1)
      SS(2)=S(2,2)
      SS(3)=S(3,3)
      SS(4)=S(1,2)
      SS(5)=S(2,3)
      SS(6)=S(1,3)
C
C
      DO 60 I=1,6
        DEFW(I)=1.5*SS(I)-BETAA(I)
```

```
        IF(DEFW(I).GE.0.0) THEN
          SGNW(I)=1.0
        ELSE
          SGNW(I)=-1.0
        END IF
C       if (ipr.eq.1) then
C       write(6,*) i,' bta1=',bta1(i),' bta2=',bta2(i),' def=',defw(i)
C       end if
   60 CONTINUE
C
      WJ2=0.0
      SJ2=0.0
C
      DO 80 I=1,6
        IF(I.LE.3) THEN
          WJ2=WJ2+DEFW(I)*DEFW(I)
        ELSE
          WJ2=WJ2+2.0*DEFW(I)*DEFW(I)
        END IF
   80 CONTINUE
C
      COW1=(2.0/3.0)**0.5
      WJSQ=WJ2**0.5
      RTW=COW1*WJSQ
      WJSE=(EXP(RTW/WK)-1.0)/WB
C
C      write(6,*) 'iii in walk',iii
      ISEE=NCT(IAA,IA,IB,IC)
      DO 40 I=1,6
        VEPS(I)=DEFW(I)*WJSE/RTW
C       EPSND(IAA,IA,IB,IC,I)=VEPS(I)
   40 CONTINUE
      NCT(IAA,IA,IB,IC)=1
C     if((ia.eq.1).and.(ib.eq.1).and.(ic.eq.1)) then
C       write(6,*) (veps(i),i=1,6)
C     end if
C
      FAC1=3.0*ET*WJSE/RTW/2.0
      FAC2=(EXP(RTW/WK)/WB/WK/RTW/RTW-WJSE/RTW**3)*ET
      BTTN=(BETAA(1)+BETAA(2)+BETAA(3))/3.0
C
C      if (ipr.eq.1) then
C     write(6,*) 'sig=',sig(2,2),' defw=',defw(2)
C     write(6,*) 'rtw=',rtw,' wjse=',wjse,' j2=',wj2
C     write(6,*) 'fac1=',fac1,' fac2=',fac2
C     write(6,*) 'defw(1)=',defw(1),' st=',bttn
C     end if
C     Now -eta*deltat is included in the formula in first 6*6 matrix.
C
      CALL MNU(24,24,ZZZ)
C
      BTTN=0.0
      ZZZ(7,1)=FAC1*2.0/3.0+FAC2*DEFW(1)*(DEFW(1)+BTTN)
      ZZZ(7,2)=-FAC1/3.0+FAC2*DEFW(1)*(DEFW(2)+BTTN)
      ZZZ(7,3)=-FAC1/3.0+FAC2*DEFW(1)*(DEFW(3)+BTTN)
      ZZZ(7,4)=FAC2*DEFW(1)*DEFW(4)
      ZZZ(7,5)=FAC2*DEFW(1)*DEFW(5)
      ZZZ(7,6)=FAC2*DEFW(1)*DEFW(6)
C
      ZZZ(8,1)=-FAC1/3.0+FAC2*DEFW(2)*(DEFW(1)+BTTN)
      ZZZ(8,2)=FAC1*2.0/3.0+FAC2*DEFW(2)*(DEFW(2)+BTTN)
      ZZZ(8,3)=-FAC1/3.0+FAC2*DEFW(2)*(DEFW(3)+BTTN)
      ZZZ(8,4)=FAC2*DEFW(2)*DEFW(4)
      ZZZ(8,5)=FAC2*DEFW(2)*DEFW(5)
      ZZZ(8,6)=FAC2*DEFW(2)*DEFW(6)
C
```

```
      ZZZ(9,1)=-FAC1/3.0+FAC2*DEFW(3)*(DEFW(1)+BTTN)
      ZZZ(9,2)=-FAC1/3.0+FAC2*DEFW(3)*(DEFW(2)+BTTN)
      ZZZ(9,3)=FAC1*2.0/3.0+FAC2*DEFW(3)*(DEFW(3)+BTTN)
      ZZZ(9,4)=FAC2*DEFW(3)*DEFW(4)
      ZZZ(9,5)=FAC2*DEFW(3)*DEFW(5)
      ZZZ(9,6)=FAC2*DEFW(3)*DEFW(6)

      ZZZ(10,1)=FAC2*DEFW(4)*(DEFW(1)+BTTN)
      ZZZ(10,2)=FAC2*DEFW(4)*(DEFW(2)+BTTN)
      ZZZ(10,3)=FAC2*DEFW(4)*(DEFW(3)+BTTN)
      ZZZ(10,4)=FAC2*DEFW(4)*DEFW(4)+FAC1
      ZZZ(10,5)=FAC2*DEFW(4)*DEFW(5)
      ZZZ(10,6)=FAC2*DEFW(4)*DEFW(6)

      ZZZ(11,1)=FAC2*DEFW(5)*(DEFW(1)+BTTN)
      ZZZ(11,2)=FAC2*DEFW(5)*(DEFW(2)+BTTN)
      ZZZ(11,3)=FAC2*DEFW(5)*(DEFW(3)+BTTN)
      ZZZ(11,4)=FAC2*DEFW(5)*DEFW(4)
      ZZZ(11,5)=FAC2*DEFW(5)*DEFW(5)+FAC1
      ZZZ(11,6)=FAC2*DEFW(5)*DEFW(6)

      ZZZ(12,1)=FAC2*DEFW(6)*(DEFW(1)+BTTN)
      ZZZ(12,2)=FAC2*DEFW(6)*(DEFW(2)+BTTN)
      ZZZ(12,3)=FAC2*DEFW(6)*(DEFW(3)+BTTN)
      ZZZ(12,4)=FAC2*DEFW(6)*DEFW(4)
      ZZZ(12,5)=FAC2*DEFW(6)*DEFW(5)
      ZZZ(12,6)=FAC2*DEFW(6)*DEFW(6)+FAC1
C
C
      ZZZ(7,7)=1.0
      ZZZ(8,8)=1.0
      ZZZ(9,9)=1.0
      ZZZ(10,10)=1.0
      ZZZ(11,11)=1.0
      ZZZ(12,12)=1.0
C
      FAC3=-FAC1/3.0*2.0
      FAC4=-FAC2*2.0/3.0
C
      ZZZ(7,13)=FAC4*DEFW(1)*DEFW(1)+FAC3
      ZZZ(8,13)=FAC4*DEFW(2)*DEFW(1)
      ZZZ(9,13)=FAC4*DEFW(3)*DEFW(1)
      ZZZ(10,13)=FAC4*DEFW(4)*DEFW(1)
      ZZZ(11,13)=FAC4*DEFW(5)*DEFW(1)
      ZZZ(12,13)=FAC4*DEFW(6)*DEFW(1)
C
      ZZZ(7,14)=FAC4*DEFW(1)*DEFW(2)
      ZZZ(8,14)=FAC4*DEFW(2)*DEFW(2)+FAC3
      ZZZ(9,14)=FAC4*DEFW(3)*DEFW(2)
      ZZZ(10,14)=FAC4*DEFW(4)*DEFW(2)
      ZZZ(11,14)=FAC4*DEFW(5)*DEFW(2)
      ZZZ(12,14)=FAC4*DEFW(6)*DEFW(2)
C
      ZZZ(7,15)=FAC4*DEFW(1)*DEFW(3)
      ZZZ(8,15)=FAC4*DEFW(2)*DEFW(3)
      ZZZ(9,15)=FAC4*DEFW(3)*DEFW(3)+FAC3
      ZZZ(10,15)=FAC4*DEFW(4)*DEFW(3)
      ZZZ(11,15)=FAC4*DEFW(5)*DEFW(3)
      ZZZ(12,15)=FAC4*DEFW(6)*DEFW(3)
C
      ZZZ(7,16)=FAC4*DEFW(1)*DEFW(4)
      ZZZ(8,16)=FAC4*DEFW(2)*DEFW(4)
      ZZZ(9,16)=FAC4*DEFW(3)*DEFW(4)
      ZZZ(10,16)=FAC4*DEFW(4)*DEFW(4)+FAC3
      ZZZ(11,16)=FAC4*DEFW(5)*DEFW(4)
      ZZZ(12,16)=FAC4*DEFW(6)*DEFW(4)
```

```
C
      ZZZ(7,17)=FAC4*DEFW(1)*DEFW(5)
      ZZZ(8,17)=FAC4*DEFW(2)*DEFW(5)
      ZZZ(9,17)=FAC4*DEFW(3)*DEFW(5)
      ZZZ(10,17)=FAC4*DEFW(4)*DEFW(5)
      ZZZ(11,17)=FAC4*DEFW(5)*DEFW(5)+FAC3
      ZZZ(12,17)=FAC4*DEFW(6)*DEFW(5)

      ZZZ(7,18)=FAC4*DEFW(1)*DEFW(6)
      ZZZ(8,18)=FAC4*DEFW(2)*DEFW(6)
      ZZZ(9,18)=FAC4*DEFW(3)*DEFW(6)
      ZZZ(10,18)=FAC4*DEFW(4)*DEFW(6)
      ZZZ(11,18)=FAC4*DEFW(5)*DEFW(6)
      ZZZ(12,18)=FAC4*DEFW(6)*DEFW(6)+FAC4
C
      DO 120 I=7,12
       DO 120 J=1,6
         ZZZ(I,J+18)=ZZZ(I,J+12)
  120 CONTINUE
C
C     Next part is -[G,epslon n]
C
      PWR=0.0
      DO 145 I=1,6
        IF(I.LE.3) THEN
          PWR=PWR+VEPS(I)*VEPS(I)
        ELSE
          PWR=PWR+2.0*VEPS(I)*VEPS(I)
        END IF
  145 CONTINUE
C
      PWR=(2.0*PWR/3.0)**0.5
C
C     WRITE(6,*) 'PLASTIC WORK IS: ',PWR
C
      IF(PWR.GT.WRO) THEN
        FAC5=(WRO/PWR)**WN5
        FAC7=-2.0*WN5*(WRO**WN5)*(PWR**(-WN5-1.0))*WN4/3.0
      ELSE
        FAC5=(PWR/WRO)**WN5
        FAC7=2.0*(PWR**(WN5-1.0))/(WRO**WN5)/3.0*WN4
      END IF
C
      FAC6=2.0*(WN3+WN4*FAC5)/3.0/PWR+FAC7
C
C     WRITE(6,*) 'FAC6: ',FAC6
C
      FAC8=2.0*WN9/3.0/PWR
      DO 150 I=1,6
        DO 150 J=1,6
          IF(I.EQ.J) THEN
            ZZZ(12+I,6+J)=FAC6*BTA1(I)*VEPS(J)-WN2
            ZZZ(18+I,6+J)=FAC8*BTA2(I)*VEPS(J)-WN11
          ELSE
            ZZZ(12+I,6+J)=FAC6*BTA1(I)*VEPS(J)
            ZZZ(18+I,6+J)=FAC8*BTA2(I)*VEPS(J)
          END IF
  150 CONTINUE
C
C     Next part: dg/dx
C
      FAC9=-((WN4*FAC5+WN3)*PWR+WN6)*ET
      FAC10=-(WN9*PWR+WN10)*ET
C
      DO 160 I=1,6
        DO 160 J=1,6
```

```
          IF(I.EQ.J) THEN
            ZZZ(12+I,12+J)=1.0+FAC9
            ZZZ(18+I,18+J)=1.0+FAC10
            ZZZ(I,J)=1.0
          END IF
  160 CONTINUE
C
      DO 333 I=1,6
        DO 333 J=1,6
          ZZZ(I,J+6)=EM2(I,J)
  333 CONTINUE
C
C     Now matrix [zzz] is formed.
C     Next step is to find the vector part.
C
      SIGVC(1)=SIG(1,1)
      SIGVC(2)=SIG(2,2)
      SIGVC(3)=SIG(3,3)
      SIGVC(4)=SIG(1,2)
      SIGVC(5)=SIG(2,3)
      SIGVC(6)=SIG(1,3)
C
C     VCTL(1..6) is the difference of d(epslon)/dt and f.
C
      DO 200 I=1,6
        VEC1(I+6)=TDELT*VEPS(I)
  200 CONTINUE
C
C     SECTM(i) is (G,epslon*d(epslon)/dt)
C
      DO 220 I=1,12
        SECTM(I)=0.0
        DO 220 J=1,6
          ZZZ(I+12,J+6)=0.0
  220 CONTINUE
C
C     GA is the state variable g
C
      FAC12=PWR*(WN3+WN4*FAC5)+WN6
      FAC13=WN9*PWR+WN10
      DO 240 I=1,6
      GA(I)=WN2*VEPS(I)-BTA1(I)*FAC12
      GA(I+6)=WN11*VEPS(I)-BTA2(I)*FAC13
C       WRITE(6,*) 'GA 2..7=Zd: ',GA(I+1)
  240 CONTINUE
C
C
      DO 280 I=1,12
        VEC1(I+12)=TDELT*GA(I)
 280  CONTINUE
C
      DO 300 I=1,6
        VEC1(I)=0.0
        IF(ABS(BTA1(I)).GT.(WAL1-1.0)) VEC1(I+12)=0.0
  300 CONTINUE
C
      CALL MNU(24,6,ZZR)
C
      DO 370 I=1,6
        DO 370 J=1,6
          ZZR(I,J)=-EM2(I,J)
  370 CONTINUE
C
C     ZZR=-D*
C
      IJOB=3
```

```
      IBOD=24
      DD1=1.0
C     DO 310 I=1,24
C       WRITE(6,*) 'I= ',I,' VEC1(I): ',VEC1(I)
C310  CONTINUE
      DO 320 I=1,19
        WRITE(6,330) (ZZZ(I,J),J=1,12)
C320  CONTINUE
C     DO 340 I=1,19
C       WRITE(6,350) (ZZZ(I,J),J=13,19)
C340  CONTINUE
 330  FORMAT(12F6.1)
 350  FORMAT(7F9.2)
C
C       For cyber:
C       CALL LINV3F(ZZZ,VEC1,IJOB,IBOD,IBOD,DD1,DD2,AINV,IER)
       CALL  LINRG(IBOD,ZZZ,IBOD,ZZZ,IBOD)
       DO 978 I=1,IBOD
       VECC(I)=0.0
       DO 978 J=1,IBOD
         VECC(I)=ZZZ(I,J)*VEC1(J)+VECC(I)
  978  CONTINUE
       DO 972 I=1,IBOD
        VEC1(I)=VECC(I)
  972  CONTINUE
C
      DETMNT=DD1*(2**DD2)
C
C     WRITE(6,*) 'The determinant of bodner matrix is: ',DETMNT
C
      IF(IER.EQ.130) THEN
        WRITE(6,*) 'INVERSE PROBLEM IN BODNER MATRIX, STOP.'
        STOP
      END IF
C
      CALL MMT(24,24,6,ZZZ,ZZR,T3D)
C     IF(IPR.EQ.1) THEN
C     DO 940 I=1,6
C        WRITE(6,970) (EM2(I,J),J=1,6)
C 940 CONTINUE
C     END IF
C
      DO 360 I=1,6
        DO 360 J=1,6
          EM2(I,J)=-T3D(I,J)
          EM4(IAA,IA,IB,IC,I*6-6+J)=EM2(I,J)
  360 CONTINUE
C      IF(IPR.EQ.1) THEN
C      DO 980 I=1,6
C        WRITE(6,970) (EM2(I,J),J=1,6)
C        WRITE(6,970) (-T3D(I,J),J=1,6)
C  980 CONTINUE
C      END IF
  970 FORMAT(6F12.1)
C
      DO 380 I=1,6
        BDLD(I)=-VEC1(I)
        BDSV(IAA,IA,IB,IC,I)=VEC1(I)
C       WRITE(6,*) 'BDLD(I):=-ZITA ',BDLD(I)
  380 CONTINUE
C
C  EM2 and BDLD will be back to subroutine cb for assemble.
C
      DO 400 I=1,24
        SVBLD(IAA,IA,IB,IC,I)=VEC1(I)
  400 CONTINUE
```

```
C
C     WRITE(6,*) 'T3D IN BODNER'
      DO 420 I=1,24
        DO 422 J=1,6
          SVT3D(IAA,IA,IB,IC,I*6-6+J)=T3D(I,J)
 422    CONTINUE
 420  CONTINUE
C
C  SVT3D and SVBLD will be used in processing face.
C
      RETURN
      END
C
C      (END WALKER)
C
C     Subroutine is used to calculate the material constants of
C     Bodner-Partom type of constitutive equations. The material
C     used is B1900+Hf. For different material, this subroutine
C     should be modified.
C
      SUBROUTINE BDCNS(TMPP)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      COMMON /BOD/ DO,ZCO,ZC1,ZC2,ZC3,ZM1,ZM2,CA1,CA2,CR1,CR2,ZNO
      COMMON /MTL/ E,EU
C
      E=198700.0+16.78*TMPP-0.1034*TMPP*TMPP
     1  +0.00001143*TMPP*TMPP*TMPP
      WRITE(6,*) 'BODNER CONST: E=',E
      EU=0.3
      DO=10000.0
      ZCO=2700.0
      ZC1=3000.0
      ZC2=2700.0
      ZC3=1150.0
      ZM1=0.27
      ZM2=1.52
      CA1=0.0
      CA2=0.0
      CR1=2.0
      CR2=2.0
      ZNO=1.055
      IF(TMPP.LT.760.0) THEN
        ZCO=2700.0
        CA1=0.0
        ZNO=1.055
      END IF
      IF((TMPP.GE.760.0).AND.(TMPP.LT.871.0)) THEN
        ZCO=2700.0-(TMPP-760.0)/111.0*300.0
        CA1=(TMPP-760.0)/111.0*0.0055
        ZNO=1.055-(TMPP-760.0)/111.0*0.025
      END IF
      IF((TMPP.GE.871.0).AND.(TMPP.LT.982.0)) THEN
        ZCO=2400.0-(TMPP-871.0)/111.0*500.0
        CA1=(TMPP-871.0)/111.0*0.0145+0.0055
        ZNO=1.03-(TMPP-871.0)/111.0*0.18
      END IF
      IF((TMPP.GE.982.0).AND.(TMPP.LT.1093.0)) THEN
        ZCO=1900.0-(TMPP-982.0)/111.0*700.0
        CA1=(TMPP-982.0)/111.0*0.23+0.02
        ZNO=0.85-(TMPP-982.0)/111.0*0.15
      END IF
        CA2=CA1
        ZC2=ZCO
C
C      WRITE(6,*) 'ELASTIC MODULUS=',E
```

```
      WRITE(6,*) 'ELASTIC MODULUS=',E,'  ZO=',ZCO,'  A=',CA1,' N=',ZNO
C
      RETURN
      END

C
C     Subroutine is used to calculate the material constants of
C     Walker type of constitutive equations. The material
C     used is B1900+Hf. For different material, this subroutine
C     should be modified.
C
      SUBROUTINE WKCNS(TMPP)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      COMMON /WAL/ WK,WB,WN2,WN3,WN4,WN5,WN6,WN8,WN9,WN10,WN11,WRO
      COMMON /MTL/ E,EU
      COMMON /WKLMT/ WAL1,WAL2
C
C
      TEM=TMPP
      WK=12.4
      WB=1.73E11
      WN2=2.41E6
      WN3=4794.0
      WN4=0.0
      WN5=0.3117
      WN6=0.0
      WN7=0.0
      WN8=0.0
      WN9=11.87
      WN10=0.0
      WN11=4.7E3
      WRO=1.0E-4
      E=1.9E5
      IF((TEM.GT.-0.01).AND.(TEM.LT.427.0)) THEN
         STE=TEM/427.0
         EU=0.322+(0.328-0.322)*STE
      END IF
      IF((TEM.GE.427.0).AND.(TEM.LT.538.0)) THEN
         STE=(TEM-427.0)/(538.0-427.0)
         EU=0.328+(0.331-0.328)*STE
      END IF
      IF((TEM.GE.538.0).AND.(TEM.LT.649.0)) THEN
        STE=(TEM-538.0)/(649.0-538.0)
        E=1.9E5+(1.8E5-1.9E5)*STE
        EU=0.331+(0.334-0.331)*STE
        WB=1.73E11+(3.862E10-1.73E11)*STE
        WN2=2.41E6+(8.27E5-2.41E6)*STE
        WN3=4794.0+(1714.0-4794.0)*STE
        WN9=11.87+(16.64-11.87)*STE
      END IF
C
      IF((TEM.GE.649.0).AND.(TEM.LT.760.0)) THEN
        STE=(TEM-649.0)/(760.0-649.0)
        E=1.8E5+(1.655E5-1.8E5)*STE
        EU=0.334+(0.339-0.334)*STE
        WK=12.4+(13.8-12.4)*STE
        WB=3.862E10+(2.55E10-3.862E10)*STE
        WN2=8.27E5
        WN3=1714.0+(1880.0-1714.0)*STE
        WN4=-585.0*STE
        WN9=16.64+(19.83-16.64)*STE
        WN10=2.44E-3*STE
      END IF
C
      IF((TEM.GE.760.0).AND.(TEM.LT.871.0)) THEN
```

```
        STE=(TEM-760.0)/(871.0-760.0)
        E=1.655E5+(1.438E5-1.655E5)*STE
        EU=0.339+(0.324-0.339)*STE
        WK=13.8+(16.6-13.8)*STE
        WB=2.55E10+(5.5E12-2.55E10)*STE
        WN2=8.27E5+(2.36E5-8.27E5)*STE
        WN3=1880.0+(621.2-1880.0)*STE
        WN4=-585.0+585.0*STE
        WN6=8.73E-4*STE
        WN9=19.83+(59.33-19.83)*STE
        WN10=2.44E-3
        WN11=4.70E3+(9.65E2-4.7E3)*STE
      END IF
C
      IF((TEM.GE.871.0).AND.(TEM.LT.982.0)) THEN
        STE=(TEM-871.0)/(982.0-871.0)
        E=1.438E5+(1.249E5-1.438E5)*STE
        EU=0.324+(0.351-0.324)*STE
        WK=16.6+(13.8-16.6)*STE
        WB=5.5E12+(4.2E10-5.5E12)*STE
        WN2=2.36E5+(9.65E4-2.36E5)*STE
        WN3=621.2+(400.0-621.2)*STE
        WN4=0.0
        WN6=8.73E-4+(4.29E-4-8.73E-4)*STE
        WN9=59.33+(136.0-59.33)*STE
        WN10=2.44E-3
        WN11=9.65E2+(-9.65E2)*STE
      END IF
C
      IF((TEM.GE.982.0).AND.(TEM.LE.1093.0)) THEN
        STE=(TEM-982.0)/(1093.0-982.0)
        E=1.249E5+(1.161E5-1.249E5)*STE
        EU=0.351
        WK=13.8+(9.0-13.8)*STE
        WB=4.2E10+(5.57E9-4.2E10)*STE
        WN2=9.65E4+(2.36E4-9.65E4)*STE
        WN3=400.0+(278.7-400.0)*STE
        WN4=0.0
        WN6=4.29E-4+(4.83E-2-4.29E-4)*STE
        WN9=136.0
        WN10=2.44E-3
        WN11=0.0
      END IF
C
      IF(TEM.GT.1093.0) THEN
        WRITE(6,*) 'MATERIAL CONSTANTS ARE NOT AVAILABLE'
        STOP
      END IF
      WAL1=WN2/WN3
      WAL2=WN11/WN9
C
        WRITE(6,*) 'WK=',WK
        WRITE(6,*) 'WB=',WB
        WRITE(6,*) 'WN2=',WN2
        WRITE(6,*) 'WN3=',WN3
        WRITE(6,*) 'WN4=',WN4
        WRITE(6,*) 'WN5=',WN5
        WRITE(6,*) 'WN6=',WN6
        WRITE(6,*) 'WN8=',WN8
        WRITE(6,*) 'WN9=',WN9
        WRITE(6,*) 'WN10=',WN10
        WRITE(6,*) 'WN11=',WN11
        WRITE(6,*) 'WRO=',WRO
        WRITE(6,*) 'WLMT1=',WAL1
        WRITE(6,*) 'WLMT2=',WAL2
C
```

```
      RETURN
      END
C
C      Subroutine THRML is for the calculationof thermal effects
C      of the structure. Newton-Raphson's iteration scheme is used
C      in the equilibrium iterations.
C
       SUBROUTINE THRML(INUM,IEL,ID,IID,L,MAXA,LD,XX,YY,ZZ,DLOADT,
     1              D,PLD,FRCO,DD,DLDINC,VTEMP,VF,D1,VFE,DDD,
     2              AM,PD,P,A,TDLD,HISINC,ACMDIS,FRCINC,XX1,YY1,
     3              ZZ1,DELTA,UPSIG,SIGMA,DLTINC,DLTTMP,STIFFN,
     4              EXLVC,BETA,UPBET,ACTFRC,GCL1,GCL2,GCL3,UCL1,
     5              UCL2,UCL3,DD1)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
C
      DIMENSION IEL(NELM,5),ID(1),IID(NNODE,5),L(1),MAXA(1)
      DIMENSION XX(1),YY(1),ZZ(1),DD(NNODE,5),D(1),PLD(1),
     1          DLOADT(1),DLDINC(1),VTEMP(1),VF(NNODE,5),
     2          D1(NNODE,5),VFE(NT,1),DDD(1),P(1),VRT(4),
     3          A(NEQT,NEQT),AM(40,40),PD(1),TDLD(1),
     4          HISINC(1),ACMDIS(1),FRCINC(1),XX1(1),YY1(1),ZZ1(1),
     5          DELTA(1),FRCO(1),UPSIG(NELM,2,2,2,9),ACTFRC(1),
     6          SIGMA(NELM,2,2,2,9),DLTINC(1),DLTTMP(1),COEEQ(5),
     7          DEFVRT(4),STIFFN(NT,NT),ETT(4),EXLVC(1),DD1(1),
     8          BETA(NELM,2,2,2,12),UPBET(NELM,2,2,2,12),GCL1(NNODE,3),
     9          GCL2(NNODE,3),GCL3(NNODE,3),UCL1(NNODE,3),
     1          UCL2(NNODE,3),UCL3(NNODE,3)
C
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /DIRCS/ IR60,IR61,IR62,IR63,IR64,IR65
      COMMON /DISVC/ IR66,IR67,IR68,IR69
      COMMON /DISV1/ IR70,IR71,IR72,IR73,IR74,IR75
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /ITESCH/ ROOT,DTLAM,SGN,IPP,TROOT,ASO,SP
      COMMON /GEO/ TO
      COMMON /CNTRL/ DETMNT
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
      COMMON /ABDFST/ ISEC
      COMMON /MTL/ E,EU
      COMMON /NMBITR/ NUM
      COMMON /CNTR/ ICNTR
      COMMON /TMPCO/ ICTMP
      COMMON /TMPEF/ IDO,NTEM,NITR,NANM,CEXPN,TMMIN,TMINC,TMMAX,TMPP
C
C
      ICTMP=1
C     (The switch to the effects of the change of temperature is on)
      ND=NEQT
      ICNTR=ICNTR+1
C
C     Initiate some variables.
C
      CALL INIT(VR(IR1),VR(IR2),VR(IR3),VR(IR43),VR(IR44),VR(IR45),
```

```
     1          VR(IR60),VR(IR61),VR(IR62),VR(IR63),VR(IR64),VR(IR65),
     2          VR(IR47),VR(IR20),VR(IR51),VR(IR58))
C
C     Begin iteration
C
      III=1
C
      DO 195 I=1,ND
        TDLD(I)=0.0
  195 CONTINUE
C
      CALL MNU(NNODE,5,DD)
C
C     Form stiffness matrix.
C
         CALL ASSMBL(III,IPT(IP1),IPT(IP2),IPT(IP3),IPT(IP4),IPT(IP5),
     1        IPT(IP9),VR(IR1),VR(IR2),VR(IR3),VR(IR6),VR(IR8),
     2        VR(IR12),VR(IR14),
     3        VR(IR15),VR(IR16),VR(IR19),
     4        VR(IR21),VR(IR23),VR(IR24),VR(IR19),VR(IR41),VR(IR50),
     5        VR(IR52),VR(IR66),VR(IR67),VR(IR68),VR(IR74))
C
C     Calculate the equivalent load vector
C
      CALL INLDV(IPT(IP1),VR(IR1),VR(IR2),VR(IR3),
     1           VR(IR14),VR(IR22),VR(IR28),VR(IR4))
C
      DO 200 I=1,NT
        DLDINC(I)=DD1(I)
C       WRITE(6,*) I,'  DD1(I)=',DD1(I)
  200 CONTINUE
C
       CALL REDC(IPT(IP4),VR(IR8),VR(IR12))
C
      DO 570 I=1,ND
        DD1(I)=0.0
        EXLVC(I)=D(I)
C       WRITE(6,*) I,'  D(I)=',D(I)
  570 CONTINUE
C     WRITE(6,*) ITRLM
C     WRITE(6,36) III
   36 FORMAT('THIS IS THE ITERATION ',I13)
C
  571 CONTINUE
C
C
        DO 444 I=1,ND
            TDLD(I)=0.0
          DO 444 J=1,ND
            TDLD(I)=TDLD(I)+A(I,J)*D(J)
  444   CONTINUE
C
      DO 505 I=1,NT
      DO 505 M=1,ND
        IF(I.EQ.L(M)) THEN
           DLOADT(I)=TDLD(M)
        END IF
  505 CONTINUE
C
C     WRITE(6,*) 'Temperature related displacement:'
      DO 506 I=1,NNODE
        DO 506 J=1,5
          VF(I,J)=DLOADT(I*5-5+J)
          DD(I,J)=DD(I,J)+VF(I,J)
C     WRITE(6,*) 'I=',I,'  ',VF(I,1),'  ',VF(I,2),'  ',VF(I,3)
  506 CONTINUE
```

```
C
C     Estimate the new coordinates
C
      TINC=1.0
      IF(III.EQ.NANM) STOP
C
      DO 900 I=1,NNODE
        XX(I)=XX(I)+VF(I,1)
        YY(I)=YY(I)+VF(I,2)
        ZZ(I)=ZZ(I)+VF(I,3)
        TMP=0.0
        DO 903 J=1,3
        GCL3(I,J)=GCL3(I,J)+TINC*(-GCL2(I,J)*VF(I,4)+GCL1(I,J)*VF(I,5))
        TMP=TMP+GCL3(I,J)*GCL3(I,J)
  903   CONTINUE
        TMP=TMP**0.5
        DO 902 J=1,3
          GCL3(I,J)=GCL3(I,J)/TMP
  902   CONTINUE
C       WRITE(6,*) 'I=',I,'  ',VF(I,1),'  ',VF(I,2),'  ',VF(I,3)
C       WRITE(6,267) I,XX(I),YY(I),ZZ(I)
  900 CONTINUE
      CALL CNND(VR(IR60),VR(IR61),VR(IR62))
C
C     Calculate internal forces
C
      CALL INTFRC(III,IPT(IP1),VR(IR1),VR(IR2),VR(IR3),
     1            VR(IR14),VR(IR22),VR(IR28),VR(IR9))
C
C     SHRINK THE INTERNAL FORCE VECTOR
C
      DO 500 I=1,NT
C     WRITE(6,*) 'PLD  ',I,'   ',PLD(I)
      DO 500 M=1,ND
        IF(I.EQ.L(M)) THEN
           FRCINC(M)=PLD(I)-FRCO(M)
           ACTFRC(M)=PLD(I)
  504     FORMAT('THE LOAD COL D,IS:',I12,' ',2F12.5)
        END IF
  500 CONTINUE
      DO 502 I=1,ND
C       WRITE(6,*) I,' RD PLD=',ACTFRC(I),' DD1=',DD1(I)
  502  CONTINUE
C
C     Check whether to step out the equilibrium iterations
C
      CALL CRITR2(III,ND,VR(IR8),VR(IR42),VR(IR59),VLINIT,ICNC1)
C
      IF(III.EQ.40) THEN
        WRITE(6,*) 'ITER LIMIT IN TEM. REACHED,STOP'
        STOP
      END IF
      IF(ICNC1.EQ.0) THEN
      ICTMP=0
C     (The switch to the effects of the change of temperature is off)
        DO 700 I=1,ND
C         WRITE(6,*) I,' 3,D=',D(I),' FRCINC',FRCINC(I)
          D(I)=-FRCINC(I)
 700    CONTINUE
        III=III+1
        GOTO 571
      END IF
C
  701 CONTINUE
      ISEC=ISEC+1
      IF(ISEC.GT.10) ISEC=10
```

```
      K=1
      DO 589 I=1,NNODE
       DO 589 J=1,5
         IF(IID(I,J).EQ.0) THEN
           ACMDIS(K)=ACMDIS(K)+DD(I,J)
           D1(I,J)=ACMDIS(K)
           K=K+1
         END IF
  589  CONTINUE
C
      DO 689 I=1,NNODE
        DO 689 J=1,5
          DD(I,J)=0.0
 689  CONTINUE
C
      ITYPE=2
C
C     Update some of the variables if equilibrium iteration is successed.
C
        CALL UPDT(ITYPE,IPT(IP3),VR(IR1),VR(IR2),VR(IR3),VR(IR12),
     1          VR(IR15),VR(IR27),VR(IR43),VR(IR44),VR(IR45),
     2          VR(IR46),VR(IR47),VR(IR20),VR(IR48),VR(IR49),
     3          VR(IR51),VR(IR58),VR(IR60),VR(IR61),VR(IR62),
     4          VR(IR63),VR(IR64),VR(IR65),VR(IR75))
C
C     Data output
C
        CALL OUTPUT(TTLD,VR(IR15),VR(IR75),VR(IR71),VR(IR1),VR(IR2),
     1                VR(IR3))
C
        IF (NITR.EQ.NUM) THEN
C
C     Write necessary data for further use.
C
         CALL WTCDT(VR(IR27),VR(IR20),VR(IR43),VR(IR44),
     1                VR(IR45),VR(IR1),VR(IR2),VR(IR3),
     1                VR(IR47),VR(IR10),VR(IR51),VR(IR58),VR(IR60),
     3                VR(IR61),VR(IR62),VR(IR15),VR(IR71),VR(IR75))
        END IF
C
      RETURN
      END
C
C     Subroutine is used to calculate the equivalent load vector
C     caused by the change of temperature.
C
      SUBROUTINE INLDV(IEL,XX,YY,ZZ,
     1                          VF,PD,PDL,PLD)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION XX(1),YY(1),ZZ(1),VF(NNODE,5),PD(1),PDL(1),PLD(1)
      DIMENSION H(2),P(2),R(8),S(8),X(8),Y(8),Z(8),ND(8),IEL(NELM,8),
     1                 VFE(40)
C
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /DIRCS/ IR60,IR61,IR62,IR63,IR64,IR65
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /RLVEC/ VR(1)
```

```
      COMMON /INTVEC/ IPT(1)
      COMMON /A3/ CL1(8),CM1(8),CN1(8),CL2(8),CM2(8),CN2(8),
     1            CL3(8),CM3(8),CN3(8)

      DO 30 I=1,NT
        PLD(I)=0.0
   30 CONTINUE

      DO 700 I=1,NELM
        I1=IEL(I,1)
        I2=IEL(I,2)
        I3=IEL(I,3)
        I4=IEL(I,4)
        I5=IEL(I,5)
        I6=IEL(I,6)
        I7=IEL(I,7)
        I8=IEL(I,8)
C
C
      CALL UPILD(I,I1,I2,I3,I4,I5,I6,I7,I8,VR(IR1),VR(IR2),VR(IR3),
     1          VR(IR14),VR(IR22),VR(IR28),VR(IR60),VR(IR61),VR(IR62))
C
C
          DO 700 J=1,8
            DO 700 K=1,5
             JJ=IEL(I,J)*5-5+K
             J1=J*5-5+K
             PLD(JJ)=PLD(JJ)+PD(J1)
  700 CONTINUE
C
      RETURN
      END
C     (END INLDV)
C
C     Subroutine UPILD is used to evaluate the equivalent load vector
C     caused by the change of temperature at every element.
C
      SUBROUTINE UPILD(IL,I1,I2,I3,I4,I5,I6,I7,I8,XX,YY,ZZ,
     1                 VF,PD,PDL,GCL1,GCL2,GCL3)
C
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION XX(1),YY(1),ZZ(1),VF(NNODE,5),PD(1),PDL(1),
     1          H(2),P(2),R(8),S(8),X(8),Y(8),Z(8),ND(8),
     2          VFE(40),GCL1(NNODE,3),GCL2(NNODE,3),GCL3(NNODE,3),
     3          HH(4),PP(4)
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /DIRCS/ IR60,IR61,IR62,IR63,IR64,IR65
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
      COMMON /A3/ CL1(8),CM1(8),CN1(8),CL2(8),CM2(8),CN2(8),
     1            CL3(8),CM3(8),CN3(8)
C
C
      ND(1)=I1
      ND(2)=I2
```

```
      ND(3)=13
      ND(4)=14
      ND(5)=15
      ND(6)=16
      ND(7)=17
      ND(8)=18
C
C
      DO 250 I=1,8
        X(I)=XX(ND(I))
        Y(I)=YY(ND(I))
        Z(I)=ZZ(ND(I))
C       WRITE(6,260)  I,X(I),Y(I),Z(I),ND(I)
        DO 250 J=1,5
          VFE(I*5-5+J)=VF(ND(I),J)
  250 CONTINUE
  260 FORMAT(1X,'THE COORDINATES OF NODE',I2,1X,'ARE:',3F12.8,I12)
C
C
      R(1)=-1.0
      S(1)=-1.0
      R(2)=1.0
      S(2)=-1.0
      R(3)=1.0
      S(3)=1.0
      R(4)=-1.0
      S(4)=1.0
C
      R(5)=0.0
      S(5)=-1.0
      R(6)=1.0
      S(6)=0.0
      R(7)=0.0
      S(7)=1.0
      R(8)=-1.0
      S(8)=0.0
C
C     WRITE(6,157)  IL
C
      DO 344 I=1,8
        CL1(I)=GCL1(ND(I),1)
        CM1(I)=GCL1(ND(I),2)
        CN1(I)=GCL1(ND(I),3)
        CL2(I)=GCL2(ND(I),1)
        CM2(I)=GCL2(ND(I),2)
        CN2(I)=GCL2(ND(I),3)
        CL3(I)=GCL3(ND(I),1)
        CM3(I)=GCL3(ND(I),2)
        CN3(I)=GCL3(ND(I),3)
  344 CONTINUE
C
      DO 348 I=1,40
        PD(I)=0.0
  348 CONTINUE
C
      H(1)=1.0
      H(2)=1.0
      P(1)=0.577352692
      P(2)=-P(1)
C
C     HH(1)=0.3478548451
C     HH(2)=H(1)
C     HH(3)=0.6521451548
C     HH(4)=H(3)
C     PP(1)=0.8611363115
C     PP(2)=-P(1)
```

```
C     PP(3)=0.3399810435
C     PP(4)=-P(3)
C
      DO 150 I=1,2
        DO 150 J=1,2
          DO 150 K=1,2
           U=P(I)
           V=P(J)
           W=P(K)
       CALL INTFC(IL,ND,I,J,K,U,V,W,X,Y,Z,VR(IR14),VR(IR28),
     1             DETJ,VR(IR31),VR(IR32),VR(IR33),VR(IR29),
     2             VR(IR37),VR(IR38),VR(IR36),VR(IR39),VR(IR40),
     3             VR(IR30),VR(IR20),VR(IR47),VR(IR54),VR(IR55))
C
C
            DO 150 M=1,40
            PD(M)=PD(M)+H(I)*H(J)*H(K)*PDL(M)*DETJ
  150 CONTINUE
C
C
      RETURN
      END
C     (END UPILD)
C
C     Subroutine UPILD is used to evaluate the equivalent load vector
C     caused by the change of temperature at every integeration point.
C
      SUBROUTINE INTFC(IL,ND,II,JJ,KK,R,S,T,X,Y,Z,VF,PDL,DETJ,BL,
     1                 TBL,TMPBL,VFE,TL,TT,TMP,EM,EM2,PDLL,SIGMA,
     1                 UPSIG,SVT3D,SVBLD)
C
C
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION X(8),Y(8),Z(8),VF(NNODE,5),PDL(1),
     1          BL(6,40),TBL(40,6),TMPBL(6,40),VFE(40),
     2          A(8),B(8),C(8),D(8),E(8),G(8),ND(8),
     3          TL(6,6),TT(6,6),TMP(6,6),EM(6,6),EM2(6,6),
     4          PDLL(40,1),SIGMA(NELM,2,2,2,9),UPSIG(NELM,2,2,2,9),
     5          SIG(3,3),GRT(3,3),DV(3,3),SVT3D(NELM,1,2,2,144),
     6          SS1(3,3),SS2(3,3),SS3(3,3),AA(3,3),SA(6,1),STA(6,1),
     7          SD(6,1),GAU(3,3),DGR(3,3),DGRT(3,3),EM3(6,6),
     8          GRD(9),GR(3,3),DW(3,3),SVBLD(NELM,2,2,2,24)
C
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /GEO/ TO
      COMMON /ABDFST/ ISEC
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
      COMMON /A3/ CL1(8),CM1(8),CN1(8),CL2(8),CM2(8),CN2(8),
     1            CL3(8),CM3(8),CN3(8)
      COMMON /TMPEF/ IDO,NTEM,NITR,NANM,CEXPN,TMMIN,TMINC,TMMAX,TMPP
C
        DO 10 I=1,8
          A(I)=0.0
          B(I)=0.0
```

```
          C(I)=0.0
          D(I)=0.0
          E(I)=0.0
          G(I)=0.0
C
   10  CONTINUE
C
C
       CALL GEOM(R,S,T,TO,X,Y,Z,DETJ,A,B,C,D,E,G)
C
C      Get the geometric property at the integration point.
C
       CALL MNU(6,40,BL)
C
       DO 380 I=1,8
C
         BL(1,I*5-4)=A(I)
         BL(4,I*5-4)=B(I)
         BL(6,I*5-4)=C(I)
C
         BL(2,I*5-3)=B(I)
         BL(4,I*5-3)=A(I)
         BL(5,I*5-3)=C(I)
C
         BL(3,I*5-2)=C(I)
         BL(5,I*5-2)=B(I)
         BL(6,I*5-2)=A(I)
C
         BL(1,I*5-1)=-D(I)*CL2(I)
         BL(2,I*5-1)=-E(I)*CM2(I)
         BL(3,I*5-1)=-G(I)*CN2(I)
         BL(4,I*5-1)=-E(I)*CL2(I)-D(I)*CM2(I)
         BL(5,I*5-1)=-G(I)*CM2(I)-E(I)*CN2(I)
         BL(6,I*5-1)=-D(I)*CN2(I)-G(I)*CL2(I)
C
         BL(1,I*5)=D(I)*CL1(I)
         BL(2,I*5)=E(I)*CM1(I)
         BL(3,I*5)=G(I)*CN1(I)
         BL(4,I*5)=E(I)*CL1(I)+D(I)*CM1(I)
         BL(5,I*5)=G(I)*CM1(I)+E(I)*CN1(I)
         BL(6,I*5)=D(I)*CN1(I)+G(I)*CL1(I)
C
  380 CONTINUE
C
        CALL MNU(6,6,TL)
C
        CALL ROTMTRX(R,S,X,Y,Z,TL)
C
C       Get the rotation transformation matrix [T].
C
        CALL TRANSP(6,6,TL,TT)
C
C      tt = t transpose.
C
       SA(1,1)=CEXPN*TMINC
       SA(2,1)=CEXPN*TMINC
       SA(3,1)=CEXPN*TMINC
       SA(4,1)=0.0
       SA(5,1)=0.0
       SA(6,1)=0.0
C
       IF((NCONS.EQ.1).AND.(III.GT.2)) THEN
         CALL MMT(6,6,1,EM2,SA,EM3)
       ELSE
         CALL MMT(6,6,1,EM,SA,EM3)
       END IF
```

```
C     WRITE(6,*)  (EM3(I,1),I=1,6)
C     Get the elastic costant and will be changed by further consideration.
C
       CALL MMT(6,6,1,TT,EM3,TMP)
C     WRITE(6,*)  (TMP(I,1),I=1,6)
C
C
      DO 720 I=1,6
        STA(I,1)=TMP(I,1)
  720 CONTINUE
C
      CALL TRANSP(6,40,BL,TBL)
      CALL MMT(40,6,1,TBL,STA,PDLL)
C
      DO 80 I=1,40
        PDL(I)=PDLL(I,1)
   80 CONTINUE
      RETURN
      END
C     ( end INFC)
C
C
      SUBROUTINE CRITR2(II,ND,DD1,FRCINC,ACTFRC,VLIMN,ICNC1)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
C
C     Subroutine CRITR2 is to build an exit criteria for the equilibrium
C     iterations.
C     input:
C     ii = The ii'th number iteration
C     DLDINC = The load increament
C     DLOADT = Te load level at that iteration.
C     PLD = The nodal force in last iteration
C     DVEC = The unknown solved in last iteration
C     VLINIT = the criteria value calculated in the first iteration.
C     Output:
C     ICONCL = The conclusion : Exit the loop or not.
C              1 = exit
C              0 = Keep inside the loop.
C
      DIMENSION DD1(1),FRCINC(1),ACTFRC(1)
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
C
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /ITESCH/ ROOT,DTLAM,SGN,IPP,TROOT,ASO,SP
C
      AINS=0.0
      COEFF=70.0
      VLIMNO=VLIMN
      VAL=0.0
      IF(II.EQ.1) THEN
        VLINT1=0.0
        DO 10 I=1,ND
          TEMP=FRCINC(I)
C         AINS=AINS+TEMP
          VLIMN=VLIMN+TEMP*TEMP
         IF (I.LT.6) THEN
```

```
          WRITE(6,90) II,I,DD1(I),FRCINC(I),TEMP,ACTFRC(I)
        END IF
 80     FORMAT('II,I,D(I),FRCINC,TEMP: ',2I4,4F12.3)
 10   CONTINUE
      VLIMN=SQRT(VLIMN)
      VAL=VLIMN
     ELSE
       DO 20 I=1,ND
          TEMP=-FRCINC(I)
          VAL=VAL+TEMP*TEMP
         IF (I.LT.6) THEN
          WRITE(6,90) II,I,DD1(I),FRCINC(I),TEMP,ACTFRC(I)
         END IF
 90      FORMAT('II,I,D(I),FRCINC,ACTF: ',2I4,4F12.4)
 20    CONTINUE
       VAL=SQRT(VAL)
     END IF

    ICNC1=0
    IF(VLIMN.GT.10.0) VLIMN=10.0
    IF((VAL*COEFF).LT.VLIMN) ICNC1=1
    WRITE(6,50) VAL*COEFF,VLIMN,ICNC1
 50 FORMAT('VAL1,CRIT1,CONCL ARE: ',2F14.3,I13)

    RETURN
    END
C
C     Subroutine RDCDT reads necessary data saved at last execution.
C     So the program can stop and resume the previous work.
C
      SUBROUTINE RDCDT(ACMDIS,SIGMA,XX1,YY1,ZZ1,XX,YY,ZZ,UPSIG,
     1                 FRCO,BETA,UPBET,GCL1,GCL2,GCL3,UCL1,UCL2,
     3                 UCL3,D1,TLTY,ANGL)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION DLOAD(1),DD1(1),DD2(1),PLD(1),ACMDIS(1),ANGL(1),
     1         SIGMA(NELM,2,2,2,9),XX(1),YY(1),ZZ(1),XX1(1),YY1(1),
     2         ZZ1(1),UPSIG(NELM,2,2,2,9),FRCINC(1),FRCO(1),
     3         BETA(NELM,2,2,2,12),UPBET(NELM,2,2,2,12),D1(NNODE,5),
     4         GCL1(NNODE,3),GCL2(NNODE,3),GCL3(NNODE,3),
     5         UCL1(NNODE,3),UCL2(NNODE,3),UCL3(NNODE,3),TLTY(1)
C
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /TMPEF/ IDO,NTEM,NITR,NANM,CEXPN,TMMIN,TMINC,TMMAX,TMPP
      COMMON /DISV1/ IR70,IR71,IR72,IR73,IR74,IR75
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /ITESCH/ ROOT,DTLAM,SGN,IPP,TROOT,ASO,SP
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
      COMMON /SQ/ SQQ
      COMMON /DISCT/ NDC,NDBC
      COMMON /OUTVR/ NPT,NPV
      COMMON /CREEP/ ICRP,NBCRP,NBDN,CRPTM,IPON
      COMMON /CNTR/ ICNTR
C
```

```
      READ(4,*)  ICNTR
      READ(4,*)  TROOT
      READ(4,*)  DTLM1
      READ(4,*)  SQQ
      READ(4,*)  TMPP
C
      IF(ICRP.EQ.1) THEN
        READ(4,*)  NBDN,CRPTM
      END IF
C
      DO 689 I=1,NNODE
        READ(4,*)  XX(I),YY(I),ZZ(I)
        WRITE(2,*)  XX(I),YY(I),ZZ(I)
        XX1(I)=XX(I)
        YY1(I)=YY(I)
        ZZ1(I)=ZZ(I)
 689  CONTINUE
      DO 687 I=1,NNODE
        READ(4,*)  (GCL1(I,J),J=1,3)
        READ(4,*)  (GCL2(I,J),J=1,3)
        READ(4,*)  (GCL3(I,J),J=1,3)
        DO 688 J=1,3
          UCL1(I,J)=GCL1(I,J)
          UCL2(I,J)=GCL2(I,J)
          UCL3(I,J)=GCL3(I,J)
 688    CONTINUE
 687  CONTINUE
C
      DO 269 I=1,NELM
      DO 269 J=1,2
      DO 269 K=1,2
      DO 269 M=1,2
      DO 269 N=1,9
        READ(4,*)  SIGMA(I,J,K,M,N)
        WRITE(2,*)  SIGMA(I,J,K,M,N)
        UPSIG(I,J,K,M,N)=SIGMA(I,J,K,M,N)
  269 CONTINUE
C
      DO 669 I=1,NEQT
        READ(4,*)  ACMDIS(I)
        WRITE(2,*)  ACMDIS(I)
  669 CONTINUE
C
      DO 730 I=1,NEQT
        READ(4,*)  FRCO(I)
        WRITE(2,*)  FRCO(I)
  730 CONTINUE
C
      IF(NCONS.EQ.1) THEN
        DO 299 I=1,NELM
        DO 299 J=1,2
        DO 299 K=1,2
        DO 299 M=1,2
        DO 299 N=1,12
          READ(4,*)  BETA(I,J,K,M,N)
          WRITE(2,*)  BETA(I,J,K,M,N)
          UPBET(I,J,K,M,N)=BETA(I,J,K,M,N)
  299   CONTINUE
      END IF
      IF(NDC.EQ.1) THEN
        DO 320 I=1,NNODE
          DO 320 J=1,5
            READ(4,*)  D1(I,J)
  320   CONTINUE
        DO 420 I=1,NDBC
          READ(4,*)  TLTY(I)
```

```
 420    CONTINUE
        IF(NPT.EQ.6) THEN
          DO 620 I=1,NDBC
            READ(4,*) ANGL(I)
 620      CONTINUE
        END IF
      END IF
C
C
      RETURN
      END
C     END RDCDT
C
C     Subroutine WTCDT write necessary data in file wrt.
C     So the program can resume the execution when desired.
C
      SUBROUTINE WTCDT(ACMDIS,SIGMA,XX1,YY1,ZZ1,XX,YY,ZZ,UPSIG,
     1                FRCO,BETA,UPBET,GCL1,GCL2,GCL3,D1,TLTY,ANGL)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION DLOAD(1),DD1(1),DD2(1),PLD(1),ACMDIS(1),ANGL(1),
     1         SIGMA(NELM,2,2,2,9),XX(1),YY(1),ZZ(1),XX1(1),YY1(1),
     2         ZZ1(1),UPSIG(NELM,2,2,2,9),FRCINC(1),FRCO(1),
     3         BETA(NELM,2,2,2,12),UPBET(NELM,2,2,2,12),TLTY(1),
     4         GCL1(NNODE,3),GCL2(NNODE,3),GCL3(NNODE,3),D1(NNODE,5)
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /DISV1/ IR70,IR71,IR72,IR73,IR74,IR75
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /ITESCH/ ROOT,DTLAM,SGN,IPP,TROOT,ASO,SP
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
      COMMON /SQ/ SQQ
      COMMON /DISCT/ NDC,NDBC
      COMMON /OUTVR/ NPT,NPV
      COMMON /CREEP/ ICRP,NBCRP,NBDN,CRPTM,IPON
      COMMON /CNTR/ ICNTR
      COMMON /TMPEF/ IDO,NTEM,NITR,NANM,CEXPN,TMMIN,TMINC,TMMAX,TMPP
C
        WRITE(7,*) ICNTR
        WRITE(7,*) TROOT
        WRITE(7,*) DTLM1
        WRITE(7,*) SQQ
        WRITE(7,*) TMPP
C
        IF(ICRP.EQ.1) THEN
          WRITE(7,*) NBDN,CRPTM
        END IF
        DO 689 I=1,NNODE
          WRITE(7,*) XX(I),YY(I),ZZ(I)
 689    CONTINUE
        DO 687 I=1,NNODE
          WRITE(7,*) (GCL1(I,J),J=1,3)
          WRITE(7,*) (GCL2(I,J),J=1,3)
          WRITE(7,*) (GCL3(I,J),J=1,3)
 687    CONTINUE
```

```
      DO 269 I=1,NELM
      DO 269 J=1,2
      DO 269 K=1,2
      DO 269 M=1,2
      DO 269 N=1,9
        WRITE(7,*) SIGMA(I,J,K,M,N)
  269 CONTINUE
      DO 669 I=1,NEQT
        WRITE(7,*) ACMDIS(I)
  669 CONTINUE
C
      DO 730 I=1,NEQT
        WRITE(7,*) FRCO(I)
  730 CONTINUE
C
C
      IF(NCONS.EQ.1) THEN
        DO 299 I=1,NELM
        DO 299 J=1,2
        DO 299 K=1,2
        DO 299 M=1,2
        DO 299 N=1,12
          WRITE(7,*) BETA(I,J,K,M,N)
  299   CONTINUE
      END IF
      IF(NDC.EQ.1) THEN
        DO 320 I=1,NNODE
          DO 320 J=1,5
            WRITE(7,*) DI(I,J)
  320   CONTINUE
        DO 420 I=1,NDBC
          WRITE(7,*) TLTY(I)
  420   CONTINUE
        IF(NPT.EQ.6) THEN
          DO 620 I=1,NDBC
            WRITE(7,*) ANGL(I)
  620     CONTINUE
        END IF
      END IF
C
C
      RETURN
      END
C     END WTCDT

C
C
C     NEXT SUBROUTINE IS USED TO UPDATA THE DIRECTION
C     COSINES OF VECTOR V1 AND V2 AT EVERY NODE.
C
C     INPUT: GCL3
C     OUTPUT: GCL1,GCL2
C
      SUBROUTINE CNND(GCL1,GCL2,GCL3)
C
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION GCL1(NNODE,3),GCL2(NNODE,3),GCL3(NNODE,3)
      COMMON /DIRCS/ IR60,IR61,IR62,IR63,IR64,IR65
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
C
C
      DO 10 I=1,NNODE
```

```
          CMD=(GCL3(I,1)*GCL3(I,1)+GCL3(I,3)*GCL3(I,3))**0.5
          GCL1(I,1)=GCL3(I,3)/CMD
          GCL1(I,2)=0.0
          GCL1(I,3)=-GCL3(I,1)/CMD
          TM1=GCL3(I,1)*GCL3(I,1)+GCL3(I,3)*GCL3(I,3)
          TM2=GCL3(I,2)*(GCL3(I,1)+GCL3(I,3))
          CMD=(TM1*TM1+TM2*TM2)**0.5
          GCL2(I,1)=0.0
          GCL2(I,2)=TM1/CMD
          GCL2(I,3)=-TM2/CMD
   10   CONTINUE
C
        RETURN
        END
C
C       Subroutine is for additional data input.
C
        SUBROUTINE RDSUP(GCL1,GCL2,GCL3,UCL1,UCL2,UCL3,ANGL)
        IMPLICIT REAL*8(A-H,O-Z)
        IMPLICIT INTEGER*8(I-N)
        DIMENSION GCL1(NNODE,3),GCL2(NNODE,3),GCL3(NNODE,3),
       1          UCL1(NNODE,3),UCL2(NNODE,3),UCL3(NNODE,3),ANGL(1)
        COMMON /DIRCS/ IR60,IR61,IR62,IR63,IR64,IR65
        COMMON /SCHALR1/ NELM,NNODE,NT
        COMMON /RLVEC/ VR(1)
        COMMON /INTVEC/ IPT(1)
        COMMON /DISCT/ NDC,NDBC
        COMMON /OUTVR/ NPT,NPV
        COMMON /RADS/ RR,ZL
C
        DO 10 I=1,NNODE
          READ(5,*) IA,(GCL3(I,J),J=1,3)
   10   CONTINUE
C
        CALL CNND(VR(IR60),VR(IR61),VR(IR62))
        DO 20 I=1,NNODE
          DO 30 J=1,3
           UCL1(I,J)=GCL1(I,J)
           UCL2(I,J)=GCL2(I,J)
           UCL3(I,J)=GCL3(I,J)
   30     CONTINUE
C          WRITE(6,*) I,' UCL1=',(UCL1(I,J),J=1,3)
C          WRITE(6,*) I,' UCL2=',(UCL2(I,J),J=1,3)
C          WRITE(6,*) I,' UCL3=',(UCL3(I,J),J=1,3)
   20   CONTINUE
C
        IF(NPT.EQ.6) THEN
          DO 50 I=1,NDBC
            READ(5,*) ANGL(I)
            WRITE(6,*) ANGL(I)
   50     CONTINUE
          READ(5,*) RR
        END IF
        IF(NPT.EQ.4.OR.NPT.EQ.5.OR.NPT.EQ.6) THEN
          READ(5,*) RR,ZL
        END IF
        RETURN
        END
C
C       Subroutine CB is to calculate the stiffness  matrix at every
C       integeration point
C
        SUBROUTINE CB(III,IL,JL,KL,ML,R,S,T,X,Y,Z,DETJ,ESM,BN1,BN2,
       1              BN3,BL,TBL,TMPEM2,SS,SS1,TMP,TL,TT,EM,EM2,UPSIG,
       2              EXED,BDLD,BDSV,EM4)
C
```

```
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION X(8),Y(8),Z(8),ESM(40,40),BN1(40,40),BN2(40,40),
     1          BN3(40,40),BL(6,40),TBL(40,6),TMPEM2(6,40),SS(9,9),
     2          SS1(9,9),TMP(6,6),TL(6,6),TT(6,6),EM(6,6),EM2(6,6),
     3          A(8),B(8),C(8),D(8),E(8),G(8),SIG(3,3),
     4          UPSIG(NELM,2,2,2,9),EXED(40),BDLD(1),
     5          BDSV(NELM,2,2,2,6),EM4(NELM,2,2,2,36)
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /A3/ CL1(8),CM1(8),CN1(8),CL2(8),CM2(8),CN2(8),
     1            CL3(8),CM3(8),CN3(8)
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /GEO/ TO
      COMMON /ABDFST/ ISEC
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
C
      IPR=0
      IF(IL.EQ.1.AND.JL.EQ.1.AND.KL.EQ.1.AND.ML.EQ.1) IPR=1
C
      CALL GEOM(R,S,T,TO,X,Y,Z,DETJ,A,B,C,D,E,G)
C
C     WRITE(6,*) R,S,T,TO,DETJ
C
      CALL MNU(6,40,VR(IR31))
C
      DO 440 I=1,3
        DO 440 J=1,3
          SIG(I,J)=UPSIG(IL,JL,KL,ML,I*3-3+J)
  440 CONTINUE
C
C     Get the linear part of matrix [B].
C
      DO 380 I=1,8
        BL(1,I*5-4)=A(I)
        BL(4,I*5-4)=B(I)
        BL(6,I*5-4)=C(I)
C
        BL(2,I*5-3)=B(I)
        BL(4,I*5-3)=A(I)
        BL(5,I*5-3)=C(I)
C
        BL(3,I*5-2)=C(I)
        BL(5,I*5-2)=B(I)
        BL(6,I*5-2)=A(I)
C
        BL(1,I*5-1)=-D(I)*CL2(I)
        BL(2,I*5-1)=-E(I)*CM2(I)
        BL(3,I*5-1)=-G(I)*CN2(I)
        BL(4,I*5-1)=-E(I)*CL2(I)-D(I)*CM2(I)
        BL(5,I*5-1)=-G(I)*CM2(I)-E(I)*CN2(I)
        BL(6,I*5-1)=-D(I)*CN2(I)-G(I)*CL2(I)
C
        BL(1,I*5)=D(I)*CL1(I)
        BL(2,I*5)=E(I)*CM1(I)
        BL(3,I*5)=G(I)*CN1(I)
        BL(4,I*5)=E(I)*CL1(I)+D(I)*CM1(I)
```

```
        BL(5,I*5)=G(I)*CM1(I)+E(I)*CN1(I)
        BL(6,I*5)=D(I)*CN1(I)+G(I)*CL1(I)
  380 CONTINUE
C
      CALL ROTMTRX(R,S,X,Y,Z,TL)
C
C      Get the rotation transformation matrix [T].
C
      CALL TRANSP(6,6,TL,TT)
C
C     tt = t transpose.
C
      CALL MMT(6,6,6,TT,EM,TMP)
      CALL MMT(6,6,6,TMP,TL,EM2)
C
      IEEC=0
      IF(ISEC.EQ.1.OR.ISEC.EQ.2) IEEC=1
      IF((NCONS.EQ.1).AND.((ISEC.NE.1).OR.(INSIDT.EQ.1)).
     1  AND.((III.EQ.1).OR.(ISEC.EQ.2))) THEN
        IF(MODEL.EQ.1) THEN
           CALL BODNER(III,IL,JL,KL,ML,SIG,VR(IR28),VR(IR40),VR(IR36),
     1                VR(IR51),VR(IR53),VR(IR54),VR(IR55),
     2                VR(IR30),VR(IR56),VR(IR57),VR(IR33))
        ELSE
           CALL WALKER(III,IL,JL,KL,ML,SIG,VR(IR28),VR(IR40),VR(IR36),
     1                VR(IR51),VR(IR53),VR(IR54),VR(IR55),
     2                VR(IR30),VR(IR56),VR(IR57),VR(IR33))
        END IF
      END IF
C
C     CALL TRANSP(6,40,BL,TBL)
      CALL TRANSP(6,40,VR(IR31),VR(IR32))
C
C     tbl = bl transpose.
C
      CALL MMT(6,6,40,EM2,BL,TMPEM2)
      CALL MMT(40,6,40,TBL,TMPEM2,ESM)
C
C     IF(IPR.EQ.1) THEN
C     DO 3 I=1,40
C      WRITE(6,*) I,'    ','ESM(I,I)=',ESM(I,I)
C 3   CONTINUE
C     END IF
C
C
      IF(NCONS.EQ.1) THEN
        DO 350 I=1,40
          EXED(I)=0.0
          DO 349 J=1,6
            EXED(I)=EXED(I)+TBL(I,J)*BDLD(J)
C         WRITE(6,*) I,J,' EXED ',EXED(I),' TBL ',TBL(I,J),' ',BDLD(J)
  349     CONTINUE
C         IF(IPR.EQ.1) WRITE(6,*) 'EXED IN CB: ',EXED(I)
C          WRITE(6,*) I,' EXED IN CB=',EXED(I)
  350   CONTINUE
      END IF
C
      CALL MNU(9,9,SS)
C
      DO 520 I=1,3
        DO 520 J=1,3
          SS(I,J)=SIG(I,J)
          SS(I+3,J+3)=SIG(I,J)
          SS(I+6,J+6)=SIG(I,J)
  520 CONTINUE
C
```

```
      DO 530 I=1,3
        SS1(I,I*3-2)=SIG(1,1)
        SS1(I,I*3-1)=SIG(1,2)
        SS1(I,I*3)=SIG(1,3)
C
        SS1(I+3,I*3-2)=SIG(2,1)
        SS1(I+3,I*3-1)=SIG(2,2)
        SS1(I+3,I*3)=SIG(2,3)
C
        SS1(I+6,I*3-2)=SIG(3,1)
        SS1(I+6,I*3-1)=SIG(3,2)
        SS1(I+6,I*3)=SIG(3,3)
  530 CONTINUE
C
C     CALL NONLM(A,B,C,D,E,G,VR(IR34),VR(IR35),VR(IR28),
C    1           VR(IR29),VR(IR30),VR(IR31),VR(IR32),VR(IR33))
C
C    Get the nonlinear part (rotation invariant) of the matrix ESM.
C
C     DO 441 I=1,40
C       DO 441 J=1,40
C         ESM(I,J)=ESM(I,J)+BN1(I,J)-2*BN2(I,J)+BN3(I,J)
C         WRITE(6,460) I,J,ESM(I,J),BN1(I,J),BN2(I,J),BN3(I,J)
  441 CONTINUE
  460 FORMAT('ESM(I,J) IS:',2I3,4F10.3)
C
      RETURN
      END
C
C     Subroutine CBUPDT is to calculate the nodal forces at every
C     integration point and update stresses for that point.
C
      SUBROUTINE CBUPDT(III,IL,ND,II,JJ,KK,R,S,T,X,Y,Z,VF,PDL,DETJ,BL,
     1                  TBL,TMPBL,VFE,TL,TT,TMP,EM,EM2,PDLL,SIGMA,
     1                  UPSIG,SVT3D,SVBLD,EM4)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION X(8),Y(8),Z(8),VF(NNODE,5),PDL(1),BL(6,40),
     1          TBL(40,6),TMPBL(6,40),VFE(40),A(8),B(8),C(8),
     2          D(8),E(8),G(8),ND(8),TL(6,6),TT(6,6),TMP(6,6),
     3          EM(6,6),EM2(6,6),PDLL(40,1),SIGMA(NELM,2,2,2,9),
     4          UPSIG(NELM,2,2,2,9),SIG(3,3),GRT(3,3),DV(3,3),
     5          SVT3D(NELM,2,2,2,114),SS1(3,3),SS2(3,3),SS3(3,3),
     6          AA(3,3),SA(6,1),SD(6,1),GAU(3,3),DGR(3,3),DGRT(3,3),
     7          AAAA(6,1),GRD(9),GR(3,3),DW(3,3),SVBLD(NELM,2,2,2,19),
     8          EM4(NELM,2,2,2,36)
C
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /GEO/ TO
      COMMON /ABDFST/ ISEC
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
      COMMON /NMBITR/ NUM
      COMMON /TMPCO/ ICTMP
      COMMON /A3/ CL1(8),CM1(8),CN1(8),CL2(8),CM2(8),CN2(8),
     1           CL3(8),CM3(8),CN3(8)
```

```
      COMMON /TMPEF/ IDO,NTEM,NITR,NANM,CEXPN,TMMIN,TMINC,TMMAX,TMPP
C
      IPR=0
      IF(II.EQ.1.AND.JJ.EQ.1.AND.KK.EQ.1) IPR=1
       DO 10 I=1,8
         A(I)=0.0
         B(I)=0.0
         C(I)=0.0
         D(I)=0.0
         E(I)=0.0
         G(I)=0.0
   10  CONTINUE
C
      CALL GEOM(R,S,T,TO,X,Y,Z,DETJ,A,B,C,D,E,G)
C
      DO 30 I=1,8
        DO 30 J=1,5
          VFE(I*5-5+J)=VF(ND(I),J)
   30 CONTINUE
C
      DO 695 I=1,9
        GRD(I)=0.0
  695 CONTINUE
C
      DO 700 I=1,8
        K=I*5
        GRD(1)=GRD(1)+A(I)*VFE(K-4)+D(I)*(-CL2(I)*VFE(K-1)
     1                                   +CL1(I)*VFE(K))
        GRD(2)=GRD(2)+B(I)*VFE(K-4)+E(I)*(-CL2(I)*VFE(K-1)
     1                                   +CL1(I)*VFE(K))
        GRD(3)=GRD(3)+C(I)*VFE(K-4)+G(I)*(-CL2(I)*VFE(K-1)
     1                                   +CL1(I)*VFE(K))
C
        GRD(4)=GRD(4)+A(I)*VFE(K-3)+D(I)*(-CM2(I)*VFE(K-1)
     1                                   +CM1(I)*VFE(K))
        GRD(5)=GRD(5)+B(I)*VFE(K-3)+E(I)*(-CM2(I)*VFE(K-1)
     1                                   +CM1(I)*VFE(K))
        GRD(6)=GRD(6)+C(I)*VFE(K-3)+G(I)*(-CM2(I)*VFE(K-1)
     1                                   +CM1(I)*VFE(K))
C
        GRD(7)=GRD(7)+A(I)*VFE(K-2)+D(I)*(-CN2(I)*VFE(K-1)
     1                                   +CN1(I)*VFE(K))
        GRD(8)=GRD(8)+B(I)*VFE(K-2)+E(I)*(-CN2(I)*VFE(K-1)
     1                                   +CN1(I)*VFE(K))
        GRD(9)=GRD(9)+C(I)*VFE(K-2)+G(I)*(-CN2(I)*VFE(K-1)
     1                                   +CN1(I)*VFE(K))
  700 CONTINUE
C
      COMP=GRD(1)+GRD(5)+GRD(9)
      CCOMP=1.0-COMP
C
      DO 720 I=1,3
        DO 720 J=1,3
          GR(I,J)=GRD(I+J*3-3)
            IF(I.EQ.J) THEN
             DGR(I,J)=GR(I,J)+1.0
            ELSE
             DGR(I,J)=GR(I,J)
            END IF
          GRT(J,I)=GR(I,J)
          DGRT(J,I)=DGR(I,J)
  720 CONTINUE
C
      DETG=DGR(1,1)*DGR(2,2)*DGR(3,3)+DGR(2,1)*DGR(3,2)*DGR(1,3)
     1    +DGR(3,1)*DGR(1,2)*DGR(2,3)-DGR(3,1)*DGR(2,2)*DGR(1,3)
     2    -DGR(2,1)*DGR(1,3)*DGR(3,3)-DGR(1,1)*DGR(3,2)*DGR(2,3)
```

```
C     WRITE(6,722) DETG
  722 FORMAT('DETG IS: ',1F10.6)
C
      DO 740 I=1,3
        DO 740 J=1,3
          GRT(I,J)=GR(J,I)
          DV(I,J)=0.5*(GRT(I,J)+GR(I,J))
          DW(I,J)=0.5*(GRT(I,J)-GR(I,J))
C         WRITE(6,741)  I,J,GRT(I,J),DV(I,J),DW(I,J)
  740 CONTINUE
  741 FORMAT('I,J,GRT,DV,DW: ',2I3,3F12.5)
C
      DO 440 I=1,3
        DO 440 J=1,3
          SIG(I,J)=UPSIG(IL,II,JJ,KK,I*3-3+J)
  440 CONTINUE
  450 FORMAT('SIG(I,J)  IS: ',2I3,1F13.5)
C
C
      CALL MNU(6,40,BL)
C
      DO 380 I=1,8
        BL(1,I*5-4)=A(I)
        BL(4,I*5-4)=B(I)
        BL(6,I*5-4)=C(I)
C
        BL(2,I*5-3)=B(I)
        BL(4,I*5-3)=A(I)
        BL(5,I*5-3)=C(I)
CC
        BL(3,I*5-2)=C(I)
        BL(5,I*5-2)=B(I)
        BL(6,I*5-2)=A(I)
CC
        BL(1,I*5-1)=-D(I)*CL2(I)
        BL(2,I*5-1)=-E(I)*CM2(I)
        BL(3,I*5-1)=-G(I)*CN2(I)
        BL(4,I*5-1)=-E(I)*CL2(I)-D(I)*CM2(I)
        BL(5,I*5-1)=-G(I)*CM2(I)-E(I)*CN2(I)
        BL(6,I*5-1)=-D(I)*CN2(I)-G(I)*CL2(I)
C
        BL(1,I*5)=D(I)*CL1(I)
        BL(2,I*5)=E(I)*CM1(I)
        BL(3,I*5)=G(I)*CN1(I)
        BL(4,I*5)=E(I)*CL1(I)+D(I)*CM1(I)
        BL(5,I*5)=G(I)*CM1(I)+E(I)*CN1(I)
        BL(6,I*5)=D(I)*CN1(I)+G(I)*CL1(I)
  380 CONTINUE
C
      CALL TRANSP(6,40,BL,TBL)
C
      CALL MNU(6,6,TL)
C
      CALL ROTMTRX(R,S,X,Y,Z,TL)
C
C     Get the rotation transformation matrix [T].
C
      CALL TRANSP(6,6,TL,TT)
C
      ICGO=0
C     IF(IPR.EQ.1) WRITE(6,*) 'III=',III,' ISEC=',ISEC
       IF  (NUM.EQ.1.AND.INSIDT.EQ.0) GOTO 345
       IF((NCONS.EQ.1).AND.(III.NE.1)) THEN
        DO 453 I=1,6
          DO 453 J=1,6
```

```
            EM2(I,J)=EM4(IL,II,JJ,KK,I*6-6+J)
  453   CONTINUE
        ICGO=1
        END IF
  345  CONTINUE
       IF(ICGO.EQ.1) GOTO 988
       CALL MMT(6,6,6,TT,EM,TMP)
       CALL MMT(6,6,6,TMP,TL,EM2)
  988  CONTINUE
C
       CALL MNU(6,40,VR(IR33))
C
       CALL MMT(6,40,1,BL,VFE,AAAA)
C
       IF(ICTMP.EQ.1) THEN
C        For thermal effects calculation
         EXPNS=CEXPN*TMINC
         AAAA(1,1)=AAAA(1,1)-EXPNS
         AAAA(2,1)=AAAA(2,1)-EXPNS
         AAAA(3,1)=AAAA(3,1)-EXPNS
       END IF
C
       CALL MMT(6,6,1,EM2,AAAA,SD)
      K=1
C
C     sd will be the stress increament
C
      CALL TRANSP(6,40,BL,TBL)
 280  CONTINUE
C
C
      IF(NUM.EQ.1.AND.INSIDT.EQ.0) GOTO 875
      IEEC=0
      IF(ISEC.EQ.1.OR.ISEC.EQ.2) IEEC=1
      IF(NCONS.EQ.1.AND.III.EQ.1) THEN
        IF(IPR.EQ.1) THEN
           WRITE(6,*) 'CALL BODSUL'
        END IF
        IF(MODEL.EQ.1) THEN
           CALL BODSUL(IL,II,JJ,KK,VR(IR31),VR(IR29),VR(IR54),
     1              VR(IR55),VR(IR51),SD,VR(IR56),VR(IR57),AAAA)
        ELSE
           CALL WALSUL(IL,II,JJ,KK,VR(IR31),VR(IR29),VR(IR54),
     1              VR(IR55),VR(IR51),SD,VR(IR56),VR(IR57),AAAA)
        END IF
C
      ELSE
        IF(NCONS.EQ.1) THEN
        IF(MODEL.EQ.1) THEN
           CALL BODS2(IL,II,JJ,KK,VR(IR31),VR(IR29),VR(IR54),
     1              VR(IR55),VR(IR51),SD,VR(IR56),VR(IR57),AAAA)
        ELSE
           CALL WALS2(IL,II,JJ,KK,VR(IR31),VR(IR29),VR(IR54),
     1              VR(IR55),VR(IR51),SD,VR(IR56),VR(IR57),AAAA)
        END IF
        END IF
      END IF
  875 CONTINUE
C
      GAU(1,1)=SD(1,1)
      GAU(2,2)=SD(2,1)
      GAU(3,3)=SD(3,1)
      GAU(1,2)=SD(4,1)
      GAU(2,1)=GAU(1,2)
      GAU(2,3)=SD(5,1)
      GAU(3,2)=GAU(2,3)
```

```
      GAU(3,1)=SD(6,1)
      GAU(1,3)=GAU(3,1)


      DO 758 I=1,3
        DO 758 J=1,3
          AA(I,J)=GAU(I,J)
  758 CONTINUE
C
C
      DO 760 I=1,3
        DO 760 J=1,3
          UPSIG(IL,II,JJ,KK,I*3-3+J)=UPSIG(IL,II,JJ,KK,I*3-3+J)
     1                              +AA(I,J)
          AA(I,J)=UPSIG(IL,II,JJ,KK,I*3-3+J)
C
  760 CONTINUE
C
C
      SA(1,1)=AA(1,1)*CCOMP
      SA(2,1)=AA(2,2)*CCOMP
      SA(3,1)=AA(3,3)*CCOMP
      SA(4,1)=AA(1,2)*CCOMP
      SA(5,1)=AA(2,3)*CCOMP
      SA(6,1)=AA(1,3)*CCOMP
C
C
      CALL MMT(40,6,1,TBL,SA,PDLL)
  900  CONTINUE
      DO 80 I=1,40
        PDL(I)=PDLL(I,1)
   80 CONTINUE
   90 FORMAT('HERE PDL(I)  IS: ',I13,1F12.7)
C
      RETURN
      END
C
C*******************************************************************************
C    Subroutine WALS2 is the solution phase using Walker's constitutive
C    equation. It is called after the first iteration.
C    Input:
C    BL-  used to find the local strain.
C    VFE- the displace increament. epsln=bl.vfe
C    SVT3D and SVBLD are the data calculated in the processing face.
C    State variable BETA(..12) are updated.
C    The derivative of the statevariable STVDF and the derivative of the
C    nonlinear strain EPSND are calculated.
C*******************************************************************************
C
      SUBROUTINE WALS2(IAA,IA,IB,IC,BL,VFE,SVT3D,SVBLD,BETA,SD,
     1                 BDSV,EM4,AA)
C
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION BL(6,40),VFE(1),SVT3D(NELM,2,2,2,144),TMVEC(24),
     1          SVBLD(NELM,2,2,2,24),BETA(NELM,2,2,2,12),SD(6,1),
     2          BDSV(NELM,2,2,2,6),EM4(NELM,2,2,2,36),AA(6,1),
     3          DBTA1(6),DBTA2(6)
C
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
```

```
    3                  IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
    4                  IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
    5                  IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /ITESCH/ ROOT,DTLAM,SGN,IPP,TROOT,ASO,SP
      COMMON /GEO/ TO
      COMMON /CONTRL/ DETMNT
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
      COMMON /WAL/ WK,WB,WN2,WN3,WN4,WN5,WN6,WN8,WN9,WN10,WN11,WRO
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /WKLMT/ WAL1,WAL2

      IPR=0
      IF((IA.EQ.1).AND.(IB.EQ.1).AND.(IC.EQ.1)) IPR=1

      DO 60 I=1,24
        TMVEC(I)=0.0
        DO 80 J=1,6
          TMVEC(I)=TMVEC(I)-SVT3D(IAA,IA,IB,IC,I*6-6+J)*AA(J,1)
 80     CONTINUE
 60   CONTINUE
C
      DO 100 I=1,6
        SD(I,1)=TMVEC(I)
        DBTA1(I)=TMVEC(I+12)
        DBTA2(I)=TMVEC(I+18)
 100  CONTINUE
C
C     WRITE(6,*) 'DSIGX=',SD(1,1),' DSY=',SD(2,1),' DSZ=',SD(3,1)
C
      DO 120 I=1,6
       BETA(IAA,IA,IB,IC,I)=BETA(IAA,IA,IB,IC,I)+DBTA1(I)
       BETA(IAA,IA,IB,IC,I+6)=BETA(IAA,IA,IB,IC,I+6)+DBTA2(I)
       IF(BETA(IAA,IA,IB,IC,I).GT.WAL1) BETA(IAA,IA,IB,IC,I)=WAL1
       IF(BETA(IAA,IA,IB,IC,I).LT.-WAL1) BETA(IAA,IA,IB,IC,I)=-WAL1
       IF(BETA(IAA,IA,IB,IC,I+6).GT.WAL2) BETA(IAA,IA,IB,IC,I+6)=WAL2
       IF(BETA(IAA,IA,IB,IC,I+6).LT.-WAL1) BETA(IAA,IA,IB,IC,I+6)=-WAL2
 120  CONTINUE
C
      RETURN
      END
C     END(WALS2)
C
C*****************************************************************************
C    Subroutine BODS2 is the solution phase using Bodner's constitutive
C    equation. It is called after the first iteration.
C    Input:
C    BL-  used to find the local strain.
C    VFE- the displace increament. epsln=bl.vfe
C    SVT3D and SVBLD are the data calculated in the processing face.
C    State variable BETA(..12) are updated.
C    The derivative of the statevariable STVDF and the derivative of the
C    nonlinear strain EPSND are calculated.
C******************************************************************************
      SUBROUTINE BODS2(IAA,IA,IB,IC,BL,VFE,SVT3D,SVBLD,BETA,SD,
     1                 BDSV,EM4,AA)
C
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION BL(6,40),VFE(1),SVT3D(NELM,2,2,2,144),TMVEC(20),
     1          SVBLD(NELM,2,2,2,24),BETA(NELM,2,2,2,12),SD(6,1),
     2          BDSV(NELM,2,2,2,6),EM4(NELM,2,2,2,36),AA(6,1),
     3          DLBET(6),TMV(19)
C
```

```
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /ITESCH/ ROOT,DTLAM,SGN,IPP,TROOT,ASO,SP
      COMMON /GEO/ TO
      COMMON /CONTRL/ DETMNT
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /BOD/ DO,ZCO,ZC1,ZC2,ZC3,ZM1,ZM2,CA1,CA2,CR1,CR2,ZNO
      COMMON /CREEP/ ICRP,NBCRP,NBDN,CRPTM,IPON
C
      IPR=0
      IF((IA.EQ.1).AND.(IB.EQ.1).AND.(IC.EQ.1)) IPR=1
C
      DO 80 I=1,19
        TMV(I)=0.0
        TMVEC(I)=0.0
        DO 80 J=1,6
          TMVEC(I)=TMVEC(I)-SVT3D(IAA,IA,IB,IC,I*6-6+J)*AA(J,1)
   80 CONTINUE
      DO 60 I=1,19
          TMV(I)=TMVEC(I)
   60 CONTINUE
C
      DO 100 I=1,6
        SD(I,1)=TMVEC(I)
C       IF(IPR.EQ.1) WRITE(6,*) 'SD IN BODS2',SD(I,1)
        DLBET(I)=TMVEC(I+13)
  100 CONTINUE
C
      DO 120 I=1,6
        BETA(IAA,IA,IB,IC,I)=BETA(IAA,IA,IB,IC,I)+DLBET(I)
        IF(BETA(IAA,IA,IB,IC,I).GT.ZC3) BETA(IAA,IA,IB,IC,I)=ZC3
        IF(BETA(IAA,IA,IB,IC,I).LT.-ZC3) BETA(IAA,IA,IB,IC,I)=-ZC3
  120 CONTINUE
      BETA(IAA,IA,IB,IC,7)=BETA(IAA,IA,IB,IC,7)+TMVEC(13)
        IF(BETA(IAA,IA,IB,IC,7).GT.ZC1) BETA(IAA,IA,IB,IC,7)=ZC1
        IF(BETA(IAA,IA,IB,IC,7).LT.(2.0*ZCO-ZC1)) BETA(IAA,IA,IB,IC,7)=
     1    2.0*ZCO-ZC1
C
      RETURN
      END
C     END(BODS2)
C
C***********************************************************************
C     Subroutine OUTPUT is used to arrange the output data. Here       C
C     D1(i,j) is the displacement matrix, where i and j are the node   C
C     number and displace component number respectively. The coordinates C
C     of node i are XX(I), YY(I), ZZ(I). The corresponding load can be C
C     calculated as the product of TROOT, load coefficient and the     C
C     applied load (given in file dt).                                 C
C***********************************************************************
C
C
      SUBROUTINE OUTPUT(TTLD,D1,ANGL,TTLY,XX,YY,ZZ)
      IMPLICIT REAL*8(A-H,O-Z)
```

```
      IMPLICIT INTEGER*8(I-N)
      DIMENSION D1(NNODE,5),ANGL(1),TTLY(1),XX(1),YY(1),ZZ(1)
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /RLVEC/ VR(1)
      COMMON /ITESCH/ ROOT,DTLAM,SGN,IPP,TROOT,ASO,SP
      COMMON /GEO/ TO
      COMMON /MTL/ E,EU
      COMMON /DISCT/ NDC,NDBC
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /INTVEC/ IPT(1)
      COMMON /OUTVR/ NPT,NPV
      COMMON /RADS/ RR,ZL
      COMMON /CREEP/ ICRP,NBCRP,NBDN,CRPTM,IPON
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      I=NSHOW1
C     NPT=1 : STRECH
C     NPT=2 : PLATE
C     NPT=3: PANEL
C     NPT=4: CYLINDRICAL SHELL UNDER AXIAL COMPRESSION
C     NPT=5: CYLINDRICAL SHELL UNDER PRESSURE
C     NPT=6: CYLINDRICAL SHELL UNDER TORSION
C
      IF(NDC.EQ.0) THEN
        IF(NPT.EQ.1) THEN
          IF(ICRP.EQ.1) THEN
            WRITE(3,*) D1(I,2)/20.0*100.0,'    ',TROOT*2.0/TO/20.0,'    ',
     1                 CRPTM
          ELSE
            WRITE(3,*) D1(I,2)/20.0*100.0,'       ',TROOT*2.0/TO/20.0
          END IF
        END IF
C
        IF(NPT.EQ.2) THEN
          DDK=3.14159**2*E*TO**3/12.0
          DDK2=3.14159**2*198700.0*TO**3/12.0
          IF(ICRP.EQ.1) THEN
            WRITE(3,*) D1(I,3)/TO,'  ',TROOT/DDK2,'  ',TROOT/TO,'  ',
     1               CRPTM
          ELSE
            WRITE(3,*) D1(I,3)/TO,'  ',TROOT/DDK,'  ',TROOT/DDK2,'  ',
     1               TROOT/TO
          END IF
          DO 55 J=1,NNODE
            WRITE(12,12) J,(D1(J,KK)*1000.0,KK=1,3)
   55     CONTINUE
   12     FORMAT (I15,3F12.5)
   23     FORMAT(7F8.3,1F7.1)
        END IF
C
        IF(NPT.EQ.3) THEN
          WRITE(3,*) -D1(I,3)*1000.0,'    ',TROOT*4.0*1000.0
          IF(NPV.EQ.1) THEN
            WRITE(12,13) D1(8,3)*1000.0,D1(13,3)*1000.0,
     1           D1(16,3)*1000.0,D1(21,3)*1000.0,TROOT*4.0*1000.0
   13       FORMAT('0.0',' ',4F10.5,1F11.5)
          END IF
        END IF
C
```

```
      IF(NPT.EQ.4) THEN
       IF(NPV.EQ.1) THEN
         KKN=9
         KKO=33
       END IF
       IF(NPV.EQ.2) THEN
         KKN=5
         KKO=19
       END IF
       IF(NPV.EQ.3) THEN
         KKN=16
         KKO=60
       END IF
       IF(NPV.EQ.4) THEN
         KKN=32
         KKO=60
       END IF
        WT=0.0
        DO 100 I=1,KKN
         WT=WT+D1(I,2)
100     CONTINUE
        WT=WT/REAL(KKN)
        WOUT=0.0
        DO 200 I=1,NNODE
          RDD=(D1(I,1)*D1(I,1)+D1(I,3)*D1(I,3))**0.5
          IF(I.LE.KKN) WOUT=WOUT+RDD
          IF(I.EQ.KKO) DPR=RDD
          WRITE(11,220) I,(D1(I,J)*1000.0,J=1,3),XX(I),
     1                  YY(I),ZZ(I),RDD*1000.0
200     CONTINUE
        WRITE(6,*) 'IN OUTPUT'
        WOUT=WOUT/REAL(KKN)
        AREA=2.0*3.1415926535*RR*TO
        WRITE(6,*) 'IN OUTPUT',' AREA=',AREA
        WRITE(9,*) WT*2000.0,'  ',WOUT*1000,'    ',TROOT/AREA
        IF(ICRP.EQ.1) THEN
          WRITE(3,*) WT*2.0/ZL,'  ',TROOT/AREA,'    ',CRPTM
        ELSE
          WRITE(3,*) WT*2.0/ZL,'    ',TROOT/AREA
        END IF
220     FORMAT(I15,6F10.6,1F12.3)
        WRITE(11,*) '*'
      END IF
      IF (NPT.EQ.5) THEN
        TEMP=0.0
       IF(NPV.EQ.1.OR.NPV.EQ.3) THEN
        DO 410 I=1,7
          TEMP=TEMP+D1(I,2)
410     CONTINUE
        TEMP=TEMP*1000.0/7.0
        WRITE(9,425) (D1(I,2)*1000.0,I=1,7),TEMP,TROOT,
     1              TROOT*RR**3*10.92/198700.0/TO**3
425      FORMAT(7F7.4,1F7.4,2F11.6)
        WRITE(11,*) TEMP,' * ',TROOT,TROOT*RR**3*10.92/198700./TO**3
        WRITE(11,427) (((XX(I)**2+ZZ(I)**2)**0.5-RR)*1000.0,I=8,11)
        WRITE(11,426) (((XX(I)**2+ZZ(I)**2)**0.5-RR)*1000.0,I=12,18)
        WRITE(11,427) (((XX(I)**2+ZZ(I)**2)**0.5-RR)*1000.0,I=19,22)
        WRITE(11,426) (((XX(I)**2+ZZ(I)**2)**0.5-RR)*1000.0,I=23,29)
        WRITE(11,427) (((XX(I)**2+ZZ(I)**2)**0.5-RR)*1000.0,I=30,33)
        WRITE(11,426) (((XX(I)**2+ZZ(I)**2)**0.5-RR)*1000.0,I=34,40)
        IF(NPV.EQ.3) THEN
          WRITE(11,427) (((XX(I)**2+ZZ(I)**2)**0.5-RR)*1000.0,I=41,44)
          WRITE(11,426) (((XX(I)**2+ZZ(I)**2)**0.5-RR)*1000.0,I=45,51)
          WRITE(3,*) -((XX(48)**2+ZZ(48)**2)**0.5-RR)*1000.0,TROOT,
     1                TROOT*RR**3*10.92/198700./TO**3
        ELSE
```

```
            IF(ICRP.EQ.1) THEN
             WRITE(3,*) -((XX(37)**2+ZZ(37)**2)**0.5-RR)*1000.0,TROOT,
     1                  CRPTM
            ELSE
             WRITE(3,*) -((XX(37)**2+ZZ(37)**2)**0.5-RR)*1000.0,TROOT,
     1                   TROOT*RR**3*10.92/198700./TO**3
            END IF
           END IF
           WRITE(11,*)
 426       FORMAT(7F10.7)
 427       FORMAT(1F10.7,'           ',1F10.7,'           ',1F10.7,
     1                '           ',1F10.7)
          ELSE
           DO 411 I=1,9
             TEMP=TEMP+D1(I,2)
 411       CONTINUE
           TEMP=TEMP*1000.0/9.0
           WRITE(9,426) (D1(I,2)*1000.0,I=1,9)
           WRITE(9,432) TEMP,TROOT,
     1                  TROOT*RR**3*10.92/198700.0/TO**3
 429        FORMAT(9F8.4)
 432        FORMAT(3F12.6)
           WRITE(11,*) TEMP,' * ',TROOT,TROOT*RR**3*10.92/198700./TO**3
           WRITE(11,424) (((XX(I)**2+ZZ(I)**2)**0.5-RR)*1000.0,I=10,14)
           WRITE(11,423) (((XX(I)**2+ZZ(I)**2)**0.5-RR)*1000.0,I=15,23)
           WRITE(11,424) (((XX(I)**2+ZZ(I)**2)**0.5-RR)*1000.0,I=24,28)
           WRITE(11,423) (((XX(I)**2+ZZ(I)**2)**0.5-RR)*1000.0,I=29,37)
           WRITE(11,424) (((XX(I)**2+ZZ(I)**2)**0.5-RR)*1000.0,I=38,42)
           WRITE(11,423) (((XX(I)**2+ZZ(I)**2)**0.5-RR)*1000.0,I=43,51)
           WRITE(11,*)
 423       FORMAT(9F8.5)
 424       FORMAT(5F10.7)
             WRITE(3,*) -((XX(47)**2+ZZ(47)**2)**0.5-RR)*1000.0,TROOT,
     1                   TROOT*RR**3*10.92/198700./TO**3
          END IF
         END IF
        ELSE
          IF(NPT.EQ.1) THEN
            WRITE(3,*) '    ',D1(I,2)/20.0*100.0,'       ',TTLD/TO/20.0
          END IF
C
          IF(NPT.EQ.2) THEN
            DDK=3.14159**2*E*TO**3/12.0
            WRITE(3,*) '    ',D1(I,3)/TO,'       ',TTLD*2.0/DDK
          END IF
          IF(NPT.EQ.6) THEN
            TOR=0.0
            DO 600 I=1,NDBC,2
              TOR=TOR+RR*(-TTLY(I)*SIN(ANGL(I))+TTLY(I+1)*COS(ANGL(I+1)))
 600        CONTINUE
             WRITE(3,*) TROOT,'     ',TOR
            DO 400 I=1,NNODE
              WRITE(11,*)  I,'    ',(XX(I)**2+ZZ(I)**2)**0.5-RR
 400        CONTINUE
            WRITE(11,*) '*'
          END IF
        END IF
        RETURN
        END
C
C     Subroutine UPDT is to update some variables when the
C     equilibrium requirement is satisfied.
C
        SUBROUTINE UPDT(ITYPE,IID,XX,YY,ZZ,DLDINC,D1,ACMDIS,XX1,
     1                  YY1,ZZ1,DELTA,UPSIG,SIGMA,DLTINC,DLTTMP,
     2                  BETA,UPBET,GCL1,GCL2,GCL3,UCL1,UCL2,UCL3,ANGL)
```

```
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)

      DIMENSION IID(NNODE,5)
      DIMENSION XX(1),YY(1),ZZ(1),D1(NNODE,5),ACMDIS(1),XX1(1),
     1          YY1(1),ZZ1(1),DELTA(1),UPSIG(NELM,2,2,2,9),
     2          SIGMA(NELM,2,2,2,9),DLTINC(1),DLTTMP(1),
     3          BETA(NELM,2,2,2,12),UPBET(NELM,2,2,2,12),
     4          GCL1(NNODE,3), GCL2(NNODE,3),GCL3(NNODE,3),
     5          UCL1(NNODE,3),UCL2(NNODE,3),UCL3(NNODE,3),ANGL(1)
C
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /DIRCS/ IR60,IR61,IR62,IR63,IR64,IR65
      COMMON /DISCT/ NDC,NDBC
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /ITESCH/ ROOT,DTLAM,SGN,IPP,TROOT,ASO,SP
      COMMON /GEO/ TO
      COMMON /OUTVR/ NPT,NPV
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
C
      ND=NEQT
      DO 689 I=1,NNODE
        XX1(I)=XX(I)
        YY1(I)=YY(I)
        ZZ1(I)=ZZ(I)
        DO 688 J=1,3
          UCL1(I,J)=GCL1(I,J)
          UCL2(I,J)=GCL2(I,J)
          UCL3(I,J)=GCL3(I,J)
 688    CONTINUE
       WRITE(6,691) I,XX1(I),YY1(I),ZZ1(I)
 691  FORMAT('COOR: ',I13,3F10.6)
 689  CONTINUE
C
      DO 269 I=1,NELM
      DO 269 J=1,2
      DO 269 K=1,2
      DO 269 M=1,2
      DO 269 N=1,9
        SIGMA(I,J,K,M,N)=UPSIG(I,J,K,M,N)
  269 CONTINUE
C
C
      IF(NCONS.EQ.1) THEN
C
      DO 169 I=1,NELM
      DO 169 J=1,2
      DO 169 K=1,2
      DO 169 M=1,2
      DO 169 N=1,12
        UPBET(I,J,K,M,N)=BETA(I,J,K,M,N)
  169 CONTINUE
      END IF
      IF(ITYPE.EQ.2) GOTO 800
```

```
C
      DO 669 I=1,ND
        DLTTMP(I)=DELTA(I)
        ACMDIS(I)=ACMDIS(I)+DLTINC(I)
  669 CONTINUE
C
      K=1
      DO 589 I=1,NNODE
       DO 589 J=1,5
         IF(IID(I,J).EQ.0) THEN
          DI(I,J)=ACMDIS(K)
          K=K+1
         END IF
  589  CONTINUE
C
      IF(NPT.EQ.6) THEN
        DO 620 I=1,NDBC
          ANGL(I)=ANGL(I)+DTLM1
  620   CONTINUE
      END IF
  800 CONTINUE
      RETURN
      END
C
C     Subroutine DISBN is used to calculate the displacement increment
C     in displacement boundary value problem for cylindrical shells.
C
      SUBROUTINE DISBN(ADVC,ANGL)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION ADVC(1),ANGL(1)
      COMMON /DISCT/ NDC,NDBC
      COMMON /DISVC/ IR66,IR67,IR68,IR69
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /OUTVR/ NPT,NPV
      COMMON /RADS/ RR,ZL
C     NPT=1 : STRECH
C     NPT=2 : PLATE
C     NPT=3: PANEL
C     NPT=4: CYLINDRICAL SHELL UNDER AXIAL COMPRESSION
C     NPT=5: CYLINDRICAL SHELL UNDER PRESSURE
C     NPT=6: CYLINDRICAL SHELL UNDER TORSION
C
      IF(NPT.EQ.1.OR.NPT.EQ.2) THEN
        DO 10 I=1,NDBC
          ADVC(I)=1.0
   10   CONTINUE
      END IF
      IF(NPT.EQ.6) THEN
        WRITE(6,*) 'RR=',RR
        DO 30 I=1,NDBC
          WRITE(6,*) I,'  ANGLE',ANGL(I)
   30   CONTINUE
        K=1
        DO 20 I=1,NDBC,2
          ADVC(K)=-RR*SIN(ANGL(I))
          ADVC(K+1)=RR*COS(ANGL(I))
C         WRITE(6,*) 'ADVC1=',ADVC(K),'  ADVC2=',ADVC(K+1)
          K=K+2
   20   CONTINUE
      END IF
      RETURN
      END
C
C      Subroutine NTCRP is for the calculation of creep buckling.
```

```
C     Newton-Raphson's iteration scheme is employed in the equilibrium
C      iterations.
C
      SUBROUTINE NTCRP(INUM,IEL,ID,IID,L,MAXA,LD,XX,YY,ZZ,DLOADT,D,
     1                PLD,FRCO,DD,DLDINC,VTEMP,VF,D1,VFE,DDD,
     2                AM,PD,P,A,TDLD,HISINC,ACMDIS,FRCINC,
     3                XX1,YY1,ZZ1,DELTA,UPSIG,SIGMA,DLTINC,DLTTMP,
     4                STIFFN,EXLVC,BETA,UPBET,ACTFRC,GCL1,
     5                GCL2,GCL3,UCL1,UCL2,UCL3,ADC,ADD,AD,ADVC,TLTY,
     6                TY1,TY2,ANGL,DBVC)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
C
      DIMENSION IEL(NELM,8),ID(1),IID(NNODE,5),L(1),MAXA(1),LD(1),
     1          XX(1),YY(1),ZZ(1),DD(NNODE,5),D(1),PLD(1),DLOADT(1),
     2          DLDINC(1),VTEMP(1),VF(NNODE,5),D1(NNODE,5),VFE(NT,1),
     3          DDD(1),VRT(4),A(NEQT,NEQT),AM(40,40),PD(1),P1(1),
     4          TDLD(1),HISINC(1),ACMDIS(1),FRCINC(1),XX1(1),YY1(1),
     5          ZZ1(1),DELTA(1),FRCO(1),UPSIG(NELM,2,2,2,9),ACTFRC(1),
     6          SIGMA(NELM,2,2,2,9),DLTINC(1),DLTTMP(1),COEEQ(5),
     7          DEFVRT(4),STIFFN(NT,NT),ETT(4),EXLVC(1),DBVC(1),
     8          BETA(NELM,2,2,2,12),UPBET(NELM,2,2,2,12),GCL1(NNODE,3),
     9          GCL2(NNODE,3),GCL3(NNODE,3),UCL1(NNODE,3),UCL2(NNODE,3),
     1          UCL3(NNODE,3),ADC(NDBC,NDBC),ADD(NDBC,NEQT),
     2          AD(NEQT,NDBC),ADVC(1),TLTY(1),TY1(1),TY2(1),ANGL(1)
C
      COMMON /SCHALR1/ NELM,NNODE,NT
      COMMON /SCHALR2/ NEQT,NSTEP,NHBW,COEF1,COEF2,NSHOW1,NSHOW2,
     1                 NSHOW3,HRZ,ITRLM,FACTOR
      COMMON /RLVEC/ VR(1)
      COMMON /INTVEC/ IPT(1)
      COMMON /PNTRIN/ IP1,IP2,IP3,IP4,IP5,IP6,IP7,IP8,IP9,IP10
      COMMON /PNTRRL/ IR1,IR2,IR3,IR4,IR5,IR6,IR7,IR8,IR9,IR10,
     1                IR11,IR12,IR13,IR14,IR15,IR16,IR17,IR18,
     2                IR19,IR20,IR21,IR22,IR23,IR24,IR25,IR26,
     3                IR27,IR28,IR29,IR30,IR31,IR32,IR33,IR34,
     4                IR35,IR36,IR37,IR38,IR39,IR40,IR41,IR42,
     5                IR43,IR44,IR45,IR46,IR47,IR48,IR49,IR50
      COMMON /UNIFBD/ IR51,IR52,IR53,IR54,IR55,IR56,IR57,IR58,IR59
      COMMON /DIRCS/ IR60,IR61,IR62,IR63,IR64,IR65
      COMMON /DISVC/ IR66,IR67,IR68,IR69
      COMMON /DISV1/ IR70,IR71,IR72,IR73,IR74,IR75
      COMMON /DISCT/ NDC,NDBC
      COMMON /UNICT/ NCONS,MODEL,ETAA,TDELT,TINIT
      COMMON /ITESCH/ ROOT,DTLAM,SGN,IPP,TROOT,ASO,SP
      COMMON /GEO/ TO
      COMMON /CNTRL/ DETMNT
      COMMON /CONTN/ INSIDT,KPDT,DTLM1
      COMMON /ABDFST/ ISEC
      COMMON /MTL/ E,EU
      COMMON /SQ/ SQQ
      COMMON /BRLIM/ LIM
      COMMON /NMBITR/ NUM
      COMMON /OUTVR/ NPT,NPV
      COMMON /CRPC/ CRPC1,CRPC2
      COMMON /CREEP/ ICRP,NBCRP,NBDN,CRPTM,IPON
      COMMON /CNTR/ ICNTR
      COMMON /TMPCO/ ICTMP
C
C
      ICTMP=0
C     (The switch to the effects of the change of temperature is off)
      ICNTR=ICNTR+1
      RTL=0.0
      LIM=0
      VLS1=0.0
```

```
      VLS2=0.0
      CALL INIT(VR(IR1),VR(IR2),VR(IR3),VR(IR43),VR(IR44),VR(IR45),
     1          VR(IR60),VR(IR61),VR(IR62),VR(IR63),VR(IR64),VR(IR65),
     2          VR(IR47),VR(IR20),VR(IR51),VR(IR58))
C
      WRITE(6,*) 'NUMBER:',INUM
      ND=NEQT
      IF(ICRP.EQ.1) THEN
       NBDN=NBDN+1
      END IF
C
C     Begin iteration
C
      III=1
C
      CALL MNU(NNODE,5,VF)
      DO 200 I=1,NT
         DLDINC(I)=DLOADT(I)
  200 CONTINUE
      DO 195 I=1,ND
          TDLD(I)=0.0
          HISINC(I)=0.0
  195 CONTINUE
C
  210 FORMAT('I,LDINC,LOADT,PLD IS',I13,3F8.3)
C
  579 CONTINUE
C
C        Form the global stiffness matrix.
C
         CALL ASSMBL(III,IPT(IP1),IPT(IP2),IPT(IP3),IPT(IP4),IPT(IP5),
     1        IPT(IP9),VR(IR1),VR(IR2),VR(IR3),VR(IR6),VR(IR8),
     2        VR(IR12),VR(IR14),
     3        VR(IR15),VR(IR16),VR(IR19),
     4        VR(IR21),VR(IR23),VR(IR24),VR(IR19),VR(IR41),VR(IR50),
     5        VR(IR52),VR(IR66),VR(IR67),VR(IR68),VR(IR74))
C
C
      ICDD=1
      WRITE(6,*) 'ASSMBL CALLED'
      IF(III.GT.2) GOTO 577
      IF(NDC.EQ.1) THEN
        CALL DISBN(VR(IR69),VR(IR75))
        DO 570 I=1,ND
C         WRITE(6,*) I,(AD(I,K),K=1,NDBC)
          DDD(I)=0.0
          DO 570 J=1,NDBC
            DDD(I)=DDD(I)+AD(I,J)*ADVC(J)
  570   CONTINUE
  533   FORMAT(I13,6F9.3)
        DO 572 I=1,ND
          DDD(I)=D(I)-DDD(I)
  572   CONTINUE
      END IF
      IF(NDC.EQ.0) THEN
        DO 573 I=1,ND
          DDD(I)=D(I)
  573   CONTINUE
      END IF
   16 FORMAT('D(I) AND DDD(I): ',I13,2F14.5)
C
  577 CONTINUE
       WRITE(6,36) III
   36 FORMAT('THIS IS THE ITERATION ',I13)
      IF(III.EQ.ITRLM) THEN
        WRITE(6,*) 'ITERATION LIMIT REACHED. STOP.'
```

```
          STOP
        END IF
C
        IF(III.EQ.1) THEN
C
          DO 755 I=1,ND
            VTEMP(I)=0.0
            DO 755 J=1,ND
              VTEMP(I)=VTEMP(I)+STIFFN(I,J)*TDLD(J)
  755     CONTINUE
C
          ASL=0.0
          DO 857 I=1,ND
            ASL=ASL+VTEMP(I)*TDLD(I)
C           WRITE(6,*) I,' TDLD=',TDLD(I)
  857     CONTINUE
           WRITE(6,*) 'ASL    ',ASL
C
          WRITE(6,*) 'TDELT=',TDELT
          WRITE(6,*) 'DETMNT=',DETMNT
          IF(ASL.LT.0.0) THEN
           WRITE(6,*) 'CHANGED SIGN OF FAC'
          END IF
          IF(DETMNT.LT.0.0) WRITE(6,*) 'NEGATIVE DETERMINT'
          DO 550 I=1,ND
            DLTTMP(I)=0.0
            DELTA(I)=0.0
            VTEMP(I)=0.0
            FRCINC(I)=0.0
  550     CONTINUE
        END IF
C
         WRITE(6,*) 'III=',III
C
  625   CONTINUE
        DO 635 I=1,ND
          DLTINC(I)=0.0
          DO 634 J=1,ND
            DLTINC(I)=DLTINC(I)+A(I,J)*EXLVC(J)
  634     CONTINUE
          IF(III.GT.1) DLTINC(I)=DLTINC(I)*CRPC1
          DELTA(I)=DLTTMP(I)+DLTINC(I)
  635   CONTINUE
C
        IF (III.EQ.1) THEN
         WRITE(6,*) 'FIRST ITERATION OF STEP ',NUM
        END IF
        I=NEQT
         WRITE(6,*) 'CURRENT ROOT ',ROOT
         WRITE(6,*) 'TDLD(25) ',TDLD(I)
         WRITE(6,*) I,' ROOT*TDLD ',ROOT*TDLD(I)
         WRITE(6,*) I,' FRCINC    ',FRCINC(I)
         WRITE(6,*) I,' HISINC ',HISINC(I)
         WRITE(6,*) I,' DLTINC ',DLTINC(I)
         WRITE(6,*) I,' DELTA ',DELTA(I)
C
C
        K=1
        KK=1
        DO 580 I=1,NNODE
         DO 580 J=1,5
           IF(IID(I,J).EQ.0) THEN
             VF(I,J)=DLTINC(K)
             DD(I,J)=DLTINC(K)
             K=K+1
           END IF
```

```
  580 CONTINUE
C
C
      DO 901 I=1,NNODE
        DO 901 J=1,5
          VFE(I*5-5+J,1)=VF(I,J)
  901 CONTINUE
  302 FORMAT('I,VFE(I)  IS: ',2I2,1F12.6)
C
C
      TINC=1.0
      DO 900 I=1,NNODE
          XX(I)=XX(I)+DD(I,1)
          YY(I)=YY(I)+DD(I,2)
          ZZ(I)=ZZ(I)+DD(I,3)
        TMP=0.0
        DO 903 J=1,3
        GCL3(I,J)=GCL3(I,J)+TINC*(-GCL2(I,J)*DD(I,4)+GCL1(I,J)*DD(I,5))
        TMP=TMP+GCL3(I,J)*GCL3(I,J)
  903   CONTINUE
        TMP=TMP**0.5
        DO 902 J=1,3
          GCL3(I,J)=GCL3(I,J)/TMP
  902   CONTINUE
C       WRITE(6,267)  I,XX(I),YY(I),ZZ(I)
  900 CONTINUE
C
C     Calculate new directional cosines for all the nodes of elements.
C
      CALL CNND(VR(IR60),VR(IR61),VR(IR62))
C
C     Calculate internal forces
C
      CALL INTFRC(III,IPT(IP1),VR(IR1),VR(IR2),VR(IR3),
     1            VR(IR14),VR(IR22),VR(IR28),VR(IR9))
C
C
      DO 500 I=1,NT
      DO 500 M=1,ND
        IF(I.EQ.L(M)) THEN
          FRCINC(M)=(PLD(I)-FRCO(M))
          ACTFRC(M)=PLD(I)
C     WRITE(6,*)  M,' PLD=',PLD(I),' FCO=',FRCO(M),' FIC=',FRCINC(M)
        END IF
  500 CONTINUE
C
        DO 549 I=1,ND
          EXLVC(I)=-FRCINC(I)
C      WRITE(6,*)  M,' FCO=',FRCO(I),' FIC=',FRCINC(I)
C     1           ,'ACTF=',ACTFRC(I)
  549   CONTINUE
C
      ISWTCH=0
      ISEC=ISEC+1
      IF(ISEC.GT.10) ISEC=10
C
      DO 665 I=1,ND
        DLTTMP(I)=DELTA(I)
C       WRITE(6,*)  'DELTA AFTER ',DELTA(I)
        ACMDIS(I)=ACMDIS(I)+DLTINC(I)
C     WRITE(6,*)  I,' ACMDIS ',ACMDIS(I)
  665 CONTINUE
C
C
      K=1
      DO 585 I=1,NNODE
```

```
      DO 585 J=1,5
        IF(IID(I,J).EQ.0) THEN
          D1(I,J)=ACMDIS(K)
          K=K+1
        END IF
585   CONTINUE
C
C     Check whether equilibrium requirement is satisfied.
C
      CALL CRITR3(III,ND,VR(IR8),VR(IR42),VR(IR59),VR(IR17),
     1            VLINIT,ICNC1,VALS)
      WRITE(6,*) 'VLINIT=',VLINIT
C     IF(ICNC1.EQ.0) THEN
C       IF(III.EQ.1) VLS1=VALS
C       IF(III.EQ.2) VLS2=VALS
C       IF(III.GT.2) THEN
C         IF(VALS.GT.VLS1.AND.VALS.GT.VLS2) THEN
C          WRITE(6,*) 'BREAK=',LIM
C          DTLM1=DTLM1/2.0
C           LIM=LIM+1
C           IF(LIM.EQ.20) THEN
C             WRITE(6,*) 'Break limit reached, stop'
C             STOP
C           END IF
C           GOTO 1000
C          ELSE
C           VLS1=VLS2
C           VLS2=VALS
C           LIM=0
C         END IF
C       END IF
C     END IF
C
      IF((ICONCL.EQ.1).OR.(ICNC1.EQ.1)) THEN
C       IF(III.LT.3.AND.NUM.LT.24) DTLM1=DTLM1*SQQ
        DTLM1=DTLM1*SQQ
        IF(III.GE.8.AND.III.LT.10) DTLM1=DTLM1/1.1
        IF(III.GE.10.AND.III.LT.15) DTLM1=DTLM1/1.2
        IF(III.GE.15) DTLM1=DTLM1/1.0
        WRITE(6,*) 'FIN VAL OF III=',III,' NDTLM1=',DTLM1
        CRPTM=CRPTM+TDELT
C
C       Write output data
C
        CALL OUTPUT(TTLD,VR(IR15),VR(IR75),VR(IR71),VR(IR1),VR(IR2),
     1              VR(IR3))
C
        ITYPE=1
C       Update some variables.
        CALL UPDT(ITYPE,IPT(IP3),VR(IR1),VR(IR2),VR(IR3),VR(IR12),
     1        VR(IR15),VR(IR27),VR(IR43),VR(IR44),VR(IR45),
     2        VR(IR46),VR(IR47),VR(IR20),VR(IR48),VR(IR49),
     3        VR(IR51),VR(IR58),VR(IR60),VR(IR61),VR(IR62),
     4        VR(IR63),VR(IR64),VR(IR65),VR(IR75))
C
      ELSE
        III=III+1
        ICDD=ICDD+1
          GOTO 577
      END IF
 670  CONTINUE
C
        DO 555 I=1,ND
          DO 555 J=1,ND
            VTEMP(I)=VTEMP(I)+STIFFN(I,J)*DELTA(J)
 555    CONTINUE
```

```
C
        ASLOP=0.0
        DO 557 I=1,ND
          ASLOP=ASLOP+VTEMP(I)*DELTA(I)
 557    CONTINUE
        ASLOP=ASLOP/ABS(ASLOP)
C
        IF (KPDT.EQ.NUM) THEN
         CALL WTCDT(VR(IR27),VR(IR20),VR(IR43),VR(IR44),
     1              VR(IR45),VR(IR1),VR(IR2),VR(IR3),
     1              VR(IR47),VR(IR10),VR(IR51),VR(IR58),VR(IR60),
     3              VR(IR61),VR(IR62),VR(IR15),VR(IR71),VR(IR75))
        END IF
 1000 CONTINUE
      RETURN
      END
C
C     Subroutine Init is used to initiate some variables
C
      SUBROUTINE INIT(XX,YY,ZZ,XX1,YY1,ZZ1,GCL1,GCL2,GCL3,
     1                UCL1,UCL2,UCL3,UPSIG,SIGMA,BETA,UPBET)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION XX(1),YY(1),ZZ(1),XX1(1),YY1(1),ZZ1(1),
     1          UPSIG(NELM,2,2,2,9),SIGMA(NELM,2,2,2,9),
     2          BETA(NELM,2,2,2,12),UPBET(NELM,2,2,2,12),
     3          GCL1(NNODE,3),GCL2(NNODE,3),GCL3(NNODE,3),
     4          UCL1(NNODE,3),UCL2(NNODE,3),UCL3(NNODE,3)
C
      COMMON /SCHALR1/ NELM,NNODE,NT
C
      DO 687 I=1,NNODE
        XX(I)=XX1(I)
        YY(I)=YY1(I)
        ZZ(I)=ZZ1(I)
        DO 686 J=1,3
          GCL1(I,J)=UCL1(I,J)
          GCL2(I,J)=UCL2(I,J)
          GCL3(I,J)=UCL3(I,J)
 686    CONTINUE
 687  CONTINUE
      DO 249 I=1,NELM
       DO 249 J=1,2
       DO 249 K=1,2
       DO 249 M=1,2
       DO 249 N=1,9
         UPSIG(I,J,K,M,N)=SIGMA(I,J,K,M,N)
 249  CONTINUE
      DO 164 I=1,NELM
      DO 164 J=1,2
      DO 164 K=1,2
      DO 164 M=1,2
      DO 164 N=1,12
        BETA(I,J,K,M,N)=UPBET(I,J,K,M,N)
 164  CONTINUE
C
      RETURN
      END
C
C     Subroutine REDC eliminates the redundant elements of a vector.
C
      SUBROUTINE REDC(L,D,DLDINC)
      IMPLICIT REAL*8(A-H,O-Z)
      IMPLICIT INTEGER*8(I-N)
      DIMENSION L(1),D(1),DLDINC(1)
      COMMON /SCHALR1/ NELM,NNODE,NT
```

```
C
      DO 500 I=1,NT
        DO 500 M=1,IDF
          IF(I.EQ.L(M)) THEN
            D(M)=DLDINC(I)
          END IF
  500 CONTINUE
C
      RETURN
      END
C      (END REDC)
C
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13. ABSTRACT *(Maximum 200 words)*

The object of the research reported herein was to develop a general mathematical model and solution methodologies for analyzing the structural response of thin, metallic shell structures under large transient, cyclic, or static thermomechanical loads. Among the system responses associated with these loads and conditions are thermal buckling, creep buckling, and ratcheting. Thus geometric and material nonlinearities (of high order) can be anticipated and must be considered in developing the mathematical model. The methodology is demonstrated through different problems of extension, shear and of planar curved beam. Moreover, importance of inclusion of large strains is clearly demonstrated, through the chosen applications. This report describes the computer program resulting from the research.

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